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In this Issue:—

THE "ECONOMY" 10-WATT AMPLIFIER

MARCH 1, 1949 VOL. 3, NO. 12 1/10

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RADIO and ELECTRONICS

Vol. 3, No. 12 — 1st March, 1949

Contents — Page

OUR COVER:

This month's cover is a photograph taken at the function held recently in Wellington in honour of Mr. A. P. Hosking, manager of the Amalgamated Wireless Valve Co. Pty., Ltd., Sydney. A full report is to be found on page 11 of this issue.

From left to right in the photograph are: Mr. G. Robertson, A.W.A.; Messrs. R. Donovan and N. H. Matthews, National Electrical and Engineering Co., Ltd.; Mr. A. P. Hosking; Mr. E. E. Pernase, A.W.A.; and Mr. I. Cosgrave, National Electrical and Engineering Co., Ltd.

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OFFICES AND LABORATORY:
Radio and Electronics (N.Z.) Ltd.,
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TELEPHONE:
Wellington 44-919.

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THE NEXT STEP—ELECTRONIC PLANNING!

In a recent issue of our British contemporary, *Electronic Engineering,* there is an article by Dr. Ashby entitled "Design for a Brain." This title would lead one to expect to read something about the E.N.I.A.C. or the A.C.E., to such an extent has the general Press seized upon such names as "electronic brain," etc., in an attempt to manufacture a sort of shorthand description for the benefit of the layman. Such, however, is very far from being the case. Dr. Ashby really does discuss the possibility of making an electronic brain, which, moreover, would live up to its name. But the most startling thing about the article is the demonstrated fact that a machine that *thinks* is now within the bounds of possibility!

Cannot it be said of a good deal of complicated machinery—and, in particular, of the vast electronic calculating machines—that they think? One might suppose so, for they can solve mathematical problems which are outside the capacity of human mathematicians to solve, but, as Dr. Ashbuy points out, any calculating machine so far invented does not really think for itself. All it does is to apply mathematical principles that are already known to those who design them. The mathematicians would no doubt quarrel with the statement that these machines can do anything that they themselves can not, and would point out that the calculating machine is purely a saver of time. For example, their greatest use will be in finding the answers to problems that are definitely soluble by known mathematical means, but which would take so many men so long to work out by ordinary means that, without the machine, the answer would not have sufficient importance to warrant the work entailed. By analogy, and taking a simplified case, no one would say that a normal adding machine can think for itself, or that, because it exists, the people who operate it are unable to perform addition.

Adding machines, then, and even the E.N.I.A.C., can not think for themselves, but Dr. Ashby has devised a machine which can. There is not room here, unfortunately, to go into the details, but at last an inanimate "gadget" has been made which behaves as if it had a brain. In other words, it is able to puzzle out for itself how to behave in order to achieve a certain physical condition, which is a "home" condition, or a state of balance. External conditions can be imposed upon it such that its condition of balance is disturbed, whereupon it proceeds to rearrange its electrical connections, automatically choosing those which tend to restore it to the home position, and rejecting those which tend to perpetuate the unbalanced state. It is quite a simple machine, relatively speaking, and consists of four units, each containing, in addition to a suspended magnet whose position provides the output voltage, a valve, a relay, and a uniselector. The four units are inter-connected in such a way that the output of each affects the other three, so that the whole is a closed feedback system. The home position is the one where all four magnets take up a central position, and any disturbance of one of them is immediately compensated by the feedbacks. If anything at all is done to disturb a set of connections which result in stability, the device automatically rearranges the connections, by operating the uniselectors, until a new system of feedbacks is found which again represents a stable system.

Now, this may not sound very like a brain, but, as Dr. Ashby points out, in principle it is. The whole thing is built round the reasoning that the behaviour of a brain is inherently similar to that of any device which employs negative feedback. The purpose of a brain is not so very mysterious. What it has to do is merely to react to certain externally imposed conditions, and see to it that its possessor acts in a certain way, which is appropriate to those conditions. To take a simple case, the purpose of the brain of an animal, when the latter is confronted with a fire, is to cause it to act in a certain way, i.e., to avoid the fire. Or, if it needs nourishment, to cause it to seek and find food. We do not as yet understand the manner in which animal brains do this (that is, the mechanics of the animal brain), but we are able to recognize the results of their operation and to realize that a machine like Dr. Ashby's produces results similar in principle.

As he rightly points out, the new machine, though only embryonic, has the germ which is required if we are to build other machines which, in "thinking," can present us with useful results. It is now theoretically possible to build something which can not only do things which it was designed to do, but which can do things *beyond the capability of the designer.* For instance, whereas by using the principles employed in ordinary calculating machines, it would be possible to make a machine which could play chess, such a machine would never be able to outplay the man who designed it, but a machine built according to Dr. Ashby's principle would be able to play chess better than any man, because it would not be limited by the features put into it, unless these were purposely arranged so that it could not "think" very well!

This is indeed a solemn thought! To many it will seem incredible that it is now possible to imagine a machine which could plan our economy for us, if fed with reams of statistics, but such is the case, and, since the demonstration of Dr. Ashby's machine, it is at least theoretically possible to do so.

AN APOLOGY

It has been brought to our notice that a circuit—namely, that of a volume expander featured in the November, 1948, issue of this journal, and entitled "A New Volume Expander Circuit with Low Distortion"—is identical in all important points with one developed by Mr. L. O. Hunter, of Auckland. In our own article it was stated implicitly that the circuit had been developed by ourselves, and no acknowledgment at all was made to Mr. Hunter.

This lapse was made all the more regrettable by virtue of the fact that Mr. Hunter, some months previously, had written to us, enclosing his own circuit, so that to him, at least, our article must have appeared as the most flagrant plagiarism.

In point of fact, Mr. Hunter's letter, and his circuit, had been filed away, all that remained being our subconscious memory of the principle involved—namely, that of using one triode, in the cathode circuit of another, and acting as a variable source of negative feedback. This idea was remembered (but not its source), and the necessary experimental work was put in hand to decide upon the exact circuit and component values. As luck would have it, we finished up with a complete circuit which is almost identical in all respects with Mr. Hunter's.

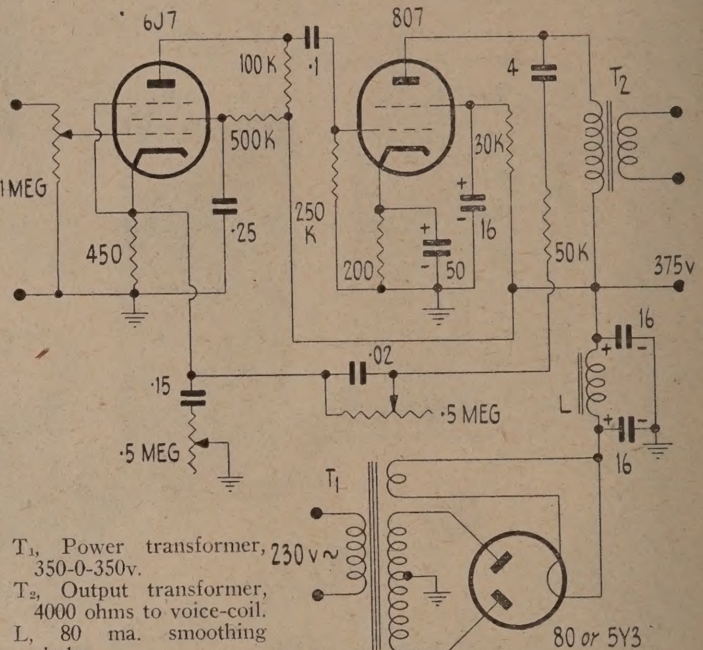
We have never had any desire to present as original, work based on that of others, and we hope that by acknowledging what was no more than an oversight, we have made sufficient amends to Mr. Hunter, and that he will accept our apology.

The RADEL ECONOMY 10-Watt AMPLIFIER

There must be many people who would like very much to build a good-quality 10-watt amplifier, but for whom a push-pull amplifier, with its fairly large H.T. requirements and more costly voltage amplifier, is rather too expensive for them to contemplate. This amplifier is one answer to these difficulties, as the story below explains.

Introductory

How often has one felt that, although the quality of one's amplifier is quite satisfactory as far as it goes, it does not go quite far enough? In other words, a small amplifier with a maximum output power of only 3 to 4 watts very often gives the impression that it is working just a little too hard for its own comfort, or for that of its listeners. This is specially noticeable with radio receivers of the ordinary commercial breed. Most times, these have but a single pentode or beam tetrode as the output stage, with a maximum of 4 watts or so output, if one is lucky. The quality at low-volume levels may be excellent, but when it is desired to take advantage of a favourite piece of music over the air or to play gramophone records through them with the aid of a turntable and pick-up, there is just not the power-handling ability to make the most of things. There is only one cure for this sort of trouble, and that is an amplifier with a greater undistorted power output. This is where the lean purse is apt to feel the strain, for almost all amplifiers over 3 or 4 watts in power seem to use a push-pull output stage, with either tetrodes or triodes. The push-pull output stage necessitates, usually, at least two more valves in the complete amplifier circuit, one to act as a phase inverter and the other making up for the fact that a push-pull stage needs twice the driving voltage of a single-ended one using the same tube type. Also, good quality dictates that the output stage be operated in pure Class A, so that the two valves necessitate a much more costly power supply than the single one. Is there an answer to these difficulties, then, and, if so, what is it?



T_1, Power transformer, 350-0-350v.
T_2, Output transformer, 4000 ohms to voice-coil.
L, 80 ma. smoothing choke.

Note.—With some transformers, it may be necessary to use a 523 or equivalent rectifier in order to get the required 375v. of H.T.

A Large Valve with Higher Plate Voltage

If we take it that any more power output than usual must be paid for in some way, and therefore that it is not feasible to get something for nothing, there is an answer. It consists simply in using a single-ended output stage, but with a larger tube than usual, which will take a higher power input and will therefore give a greater power output.

Let us consider this proposition for a moment. At first sight it might seem that by so doing we have gained nothing at all in cutting down the cost of the power output, when reckoned in watts per 20s. In the first place, a larger power valve means a greater H.T. voltage, or current, or both, and this has to be paid for. Secondly, the large valve itself can be expected to cost more than usual. Thirdly, the usual small output transformer will not handle the extra power output, and will have to be replaced with a larger and more costly component. Where, then, is the gain?

It is like this. Here we are proposing to use an 807 instead of a 6V6 or 6F6, or even a 6L6. The 807 will certainly cost more than a single 6V6 or 6L6, but in these days of war-surplus valves one will be unlucky if it costs as much as *two* 6V6's. But in reckoning the valve cost, we have to remember that a single 807 takes no more driving (from the cost angle) than does a single 6V6. In fact, a single 6J7 is all we need in the way of a voltage amplifier, even allowing for the fact that we will use negative feedback. As against this, the small push-pull amplifier needs at the very least two valves as voltage-amplifier and phase inverter. Thus, by using the 807, we have saved ourselves one whole valve. The increase in possible power output has thus increased the valve cost compared with the low-powered amplifier, but not as compared with the push-pull amplifier which is the alternative. As regards the power supply, we will use a plate voltage of 375 on the 807, the screen voltage will be 250, while the combined plate and screen currents will be 75 ma. as against 99 ma. for a pair of 6V6's. Thus, an 80 ma. transformer will do for the 807 amplifier, whereas a 100 ma. one would have to be used for the push-pull of 6V6's. This is a real saving, especially when it is realized that the smoothing choke, too, benefits by the reduced rating. On balance, then, the single 807 has it all over the push-pull beam tetrode amplifier, and even more so over the push-pull triode amplifier. For instance, a pair of 6A3's, in pure Class A, need a power supply capable of giving out 120 ma. for a power output of only 7 watts. The single 807 is rated as giving 11.3 watts. But what about the higher plate voltage? Will that not necessitate a costlier power transformer? The answer is, of course, "Yes," but not nearly so much more than would one of higher current rating.

The whole argument boils down to the fact that the *circuit of this amplifier demonstrates the cheapest way of getting more than ten watts of audio power,* and this will no doubt appeal to a great number of people. If, for example, one is building a low-powered phone transmitter and required 10 watts of audio from the modulator, either to plate modulate a 20-watt input to the final amplifier or for cathode modulation of a higher input power, then the same considerations of economy apply. Since the circuit employs a high degree of negative feedback, it can also be used as the driving stage for a high-powered Class B audio amplifier. In fact, it has a number of uses apart from that of forming the output end of a radio set or an electric gramophone.

The Circuit

This really requires very little comment, as it looks very similar to a good many others that have been standard for lower-powered amplifiers. In fact, there are hardly any "frills," from the circuit point of view, and yet the quality is excellent, owing to the large amount of negative feedback used, and also because of this we were enabled to incorporate independent bass and treble boost controls. This is a feature that will attract many constructors. The operation of the controls has no effect at all on the middle range of frequencies, and so leaves the apparent volume unchanged. Nor has one control any effect at all on the other.

The feedback is inserted from the plate of the output stage to the cathode of the voltage amplifier. This is a much better scheme than is feeding back over the output stage only. If this is done, as it often is in small sets using a single-ended output stage, one very grave difficulty occurs. Without any feedback at all, the audio signal required to swing the grid of the output stage is 15.6 volts peak. This is quite small, but if feedback is now taken from the plate of the output stage back to its grid, the required driving voltage is much greater. In fact, if the voltage gain reduction (due to the feedback) is three times, then the 807 will need a peak signal of 46.8 volts before full output is reached. This is not so bad, as it is within the capabilities of a 6J7 to supply without too much distortion, but if the feedback is increased very much beyond this point, we reach the vicious circle that the more we decrease the distortion of the output stage, the more we increase the distortion of the driver, because this valve is not beneficially affected by the feedback, which, on the other hand, calls upon the driver to deliver more and more voltage to drive the output tube. In other words, with circuits of that kind, there is a very definite limit to the amount of negative feedback that is beneficial. "Too much spoils the flavour."

But with the kind of circuit used here, where the feedback is taken round both stages of the amplifier, no such trouble occurs. The 807 still needs only 15.6 peak volts for full output, however much feedback is applied, and the reduction of voltage gain caused by the feedback shows up as an increase in the voltage required *to drive the 6J7.* Since without feedback this was only a small fraction of a volt, we can put on a very large amount of feedback, and still the signal needed to drive the 6J7 is only a small one.

In this particular instance, the voltage required at the amplifier input is approximately 2 volts for full output; no one is going to worry very much about getting an undistorted output from the preceding valve of this small figure. The gain reduction factor used is over 6 times. This means that, whatever the distortion may be at any power output level without feedback, the actual distortion may be at any power output level without feedback, the actual distortion with feedback in operation will be less than one-sixth of the amount. For example, if the distortion at full output without feedback is reckoned to be 10 per cent., then in the present circuit it should be only a little more than 1 per cent., and correspondingly less at lower power levels. Thus, from the point of view of quality, there will be few who will quarrel with this amplifier.

Frequency Response

As to frequency response, when measured under the most difficult conditions (that is, with a resistance load), it was found to be 2.5 db. down at 10,000 cycles per second and 1 db. down at 30 c/sec., in both cases with the boost controls inoperative. With these at maximum, the effect at low frequencies is to give an almost linear rise from 300 c/sec. to 35 c/sec., the boost at the latter frequency being 10.5 db. At the high-frequency end, the boost starts at approximately 1500 c/sec. and rises to 10.5 db. at 10,000 c/sec.

Construction and Lay-out

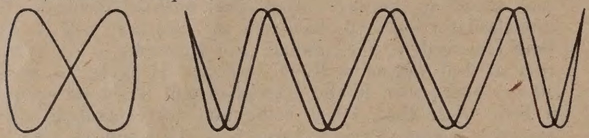
In next month's issue of *Radio and Electronics* we will reproduce photographs and chassis diagrams of a suitable mechanical layout, but for such a simple job many of our more experienced readers will need no more than the circuit and description already given.

A Five-inch Oscilloscope Employing Unit Construction

PART 5

Using the Oscilloscope to Measure Audio Frequencies

If even a single known audio frequency is available (and there is always one present in the shape of the 50 c/sec. mains), the 'scope, again without a time-base, but with the aid of either or both of its amplifiers, can be used to measure unknown audio frequencies. This is done by the well-known method of drawing Lissajous figures. These figures are the patterns obtained when one voltage is applied to the X axis, and another is applied to the Y axis. The so-called phase-shift patterns we have described at such length are really only special cases of this type of pattern, in which the two voltages have identical frequencies.



(*a*) *Fig.* 8 (*b*)

To carry out the method, the known frequency is applied, usually, to the X plates, and the unknown one to the Y plates. When one of the frequencies is an exact multiple of the other, the pattern takes the form of a stationary closed loop, the complexity of which depends on the ratio of the frequencies. If the ratio is 1:1, the only possible patterns are a straight line, a circle, or an ellipse, and as we have seen already, the form of pattern obtained depends on the relative phase of the voltages. When the ratio is larger, the variety of patterns possible increases very rapidly, and it might seem at first sight that the whole thing would become very complicated. In practice, though, comparing the frequency of two voltages is quite simple to carry out, and by means of a simple rule, ratios up to 8:1 or even more can be determined very readily. Figs. 8 and 9 show three Lissajous figures for various ratios. In all three cases, the lowest frequency is giving the horizontal deflection. Fig. 8 (*a*) shows a ratio of 2:1, and at 8 (*b*) is a ratio of 8:1. The rule for finding the ratio is as follows.

Imagine two straight-edges, one horizontal, and the other vertical, and arranged so that the pattern touches both of them. The required ratio is found by counting the number of times the pattern touches the horizontal ruler, and then the number of times it touches the vertical one. The two numbers obtained are the numbers of the ratio. For example, Fig. 8 (*a*) touches the horizontal edge twice, and the vertical edge once. The ratio is therefore 2:1. Since the reference frequency is known, the unknown frequency is now known to be 2/1 times the former. Fig. 8 (*b*) illustrates the more complicated case of 8:1, and shows the one type of pattern which can give misleading results. If a very slight change were made in the relative phases of the two frequencies, the pattern would change so that the peaks which are very close together would coincide. If this happened, the count would be 5:1, which is quite wrong. In practice, it is easy to guard against these kinds of error, as it almost always happens that the frequency of one or the other of the waveforms is variable. The ambiguity is caused simply by the fact that the forward and return traces are exactly superimposed, and when one of the frequencies is variable, the pattern can be observed to pass through the "wrong" stage, and to look like Fig. 8 (*b*) at two positions. The ambiguity really occurs only when the "wrong" pattern arrives when everything is exactly stationary, since most often it will happen when the frequencies are not exactly synchronized, so that every now and then the changing picture can be seen to drift through the pattern which gives the wrong answer. Thus, although frequency comparison by the Lissajous figure method is very easily carried out, a little experience in interpreting the patterns is needed. This can be gained by anyone who has a 'scope, even if it means building up a rough variable-frequency audio oscillator for the purpose. It is well worth doing, however, as it is often extremely useful to be able to do this.

Many other types of Lissajous figure are obtained

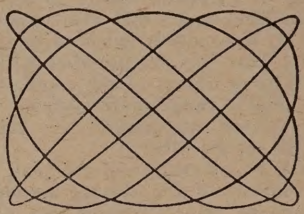


Fig. 9

between the easily recognized ones which represent ratios like, say, 4:1 and 5:1. For example, a stationary pattern is obtained whenever the ratio is an integral one. Thus, ratios of 3:2, 4:3, and 5:4 will give a stationary pattern, and all such pictures are readily recognized by the fact that the trace crosses over itself many times more than it does with the simpler patterns. Fortunately, however, the method of finding what ratio a given pattern represents is exactly the same as the one we have used for the simpler cases of 2:1, 3:1, etc. Fig. 9 shows the pattern for a ratio of 5:4. If in doubt about this, it is only necessary to place a ruler first along one side of the pattern and then along the other, each time counting the number of times that the trace touches the ruler. Remember, too, that if the unknown frequency is causing the X deflection, the count for the *vertical* position of the ruler is on top of the ratio, and if it is on the Y plates, the count for the *horizontal* position of the ruler is placed on top. In Fig. 9 the unknown has been assumed to be the one giving the Y deflection. Thus, its frequency is 5.4 times the known frequency.

In practice, the ease with which this latter type of pattern can be observed depends mainly on the stability of the frequencies concerned. This is because only a very slight frequency shift in one of the voltages is enough to lose entirely a pattern such as would be got from a ratio of 8:7 or 9:8.

It can be seen that a single known frequency is able to give calibration points for a larger number of frequencies. For example, suppose the only known frequency available is the 50 c/sec. mains. It would be possible to calibrate a variable frequency oscillator up to at least 400 c/sec., and probably higher, using the 'scope and the mains as the reference frequency. The fractional ratios would enable a number of frequencies quite close to 50 c/sec. to be identified. For instance, if the pattern for 5:4 were obtained, the "unknown" frequency would be only 62.5 c/sec. Thus, by using ratios of 3:2, 5:4, 4:3,

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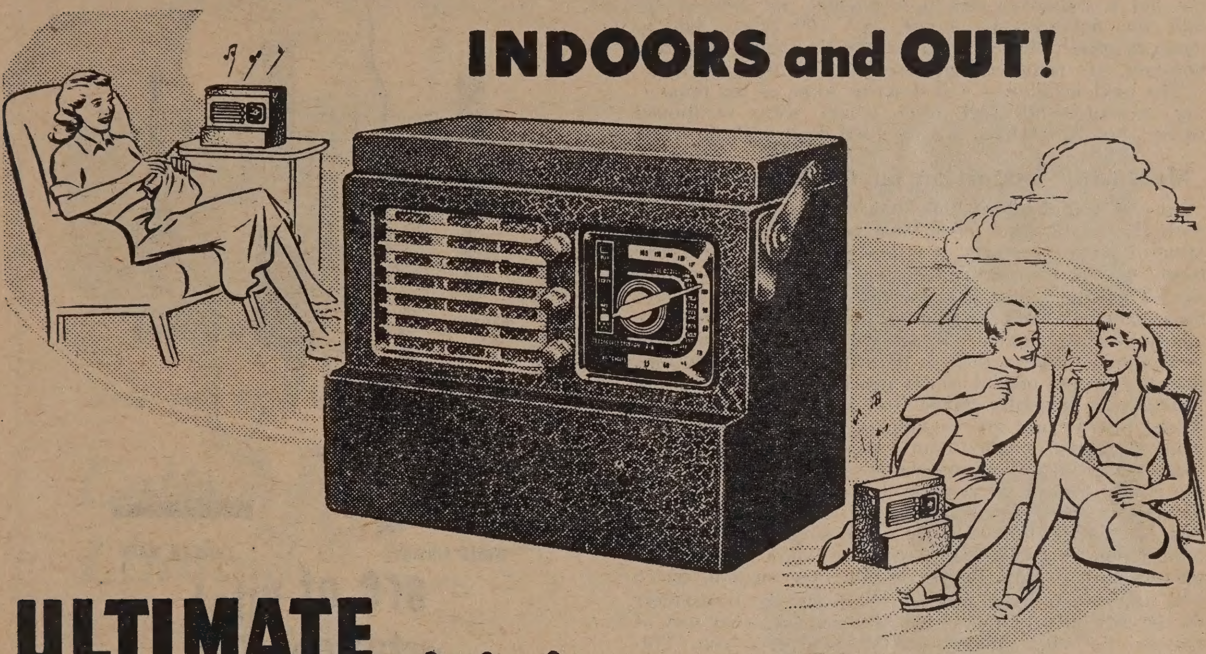

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2:1, etc., exact calibration of the oscillator could be had at frequencies of 75, 62.5, 66.6, 100, etc., c/sec. These would enable a curve to be drawn for the dial reading—versus frequency, and from this, the dial readings for more useful frequencies could be read.

There are even possibilities in the Lissajous figure method that have not been mentioned in this article. For example, if the unknown frequency is fixed, and gives a pattern very similar to one of the integral ratio patterns, but not a stationary one, it is possible not only to say that the unknown is almost, say, 100 c/sec., but to measure just what the difference is. Such methods, however, are rather outside the scope of this article.

The next instalment will describe some of the remaining measurements and tests which were mentioned earlier, but which have not yet been dealt with in detail.

Measuring Distortion on the Oscilloscope

At the beginning of this article, it was stated that, with the oscilloscope alone, and without even an oscillator of pure waveform, it is possible to make measurements of the degree of distortion arising in an amplifier. This may come as a surprise to many who have been under the impression that to make any measurements of distortion at all, an expensive wave-analyser is necessary. Where, then, is the catch? It is simply this, that the 'scope method is not nearly as sensitive as are instruments specially made for measuring distortion. These instruments are capable of detecting and measuring distortion smaller than 1 per cent. in total amplitude, and it is by no means possible to do this with the oscilloscope. It is possible, however, to measure distortions of the order of 5 per cent. For many purposes, this is enough. For example, supposing you have just built a new modulator and want to know whether its performance is satisfactory or not. One method, which will probably be tried anyway, is to put the transmitter on the air with the new modulator and see what sort of reports the other fellows on the band give you. This is very nice, but it will not give any accurate idea of whether the new amplifier is better than the last. If an easy method of measuring distortion is available, it is much more satisfactory from all points of view if this is used to tell you whether the distortion at maximum power output is within reasonable limits or not. In this case, there is no need to worry about high-fidelity specifications, because such is not at all necessary, either from the points of view of frequency response or distortion. For communication purposes, the modulator can be considered quite satisfactory if the distortion is no greater than 5 per cent. at maximum output. This is where the present method comes in. First of all, it is necessary to have some form of oscillator to provide a steady signal into the amplifier to be measured. This does not need to be a pure sine-wave at all, and any rough oscillator built up for the purpose will do as long as its frequency can be varied, say, between 300 and 1500 c/sec. Many circuits have appeared of simple phase-shift, or resistance-capacity oscillators that will suit admirably, and can be built up very speedily if they are wanted. A variable output voltage is not needed, nor is an oscillator whose output stays constant at different frequencies. In fact, almost anything will do.

The method used is to display the phase-shift picture on the screen and to make an accurate tracing of it on a piece of paper. Thereafter, by the methods to be described, a few simple pieces of arithmetic are all that is needed to obtain the percentages of harmonics up to and including the seventh, if desired. An advantage of the method is that if one only wants to find harmonics

(Continued on page 44.)

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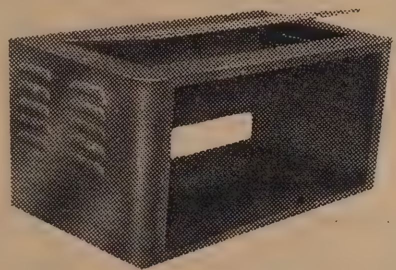

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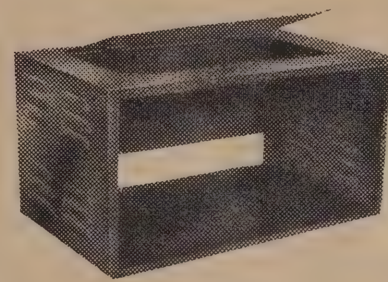

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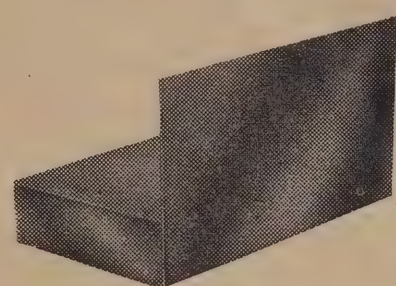

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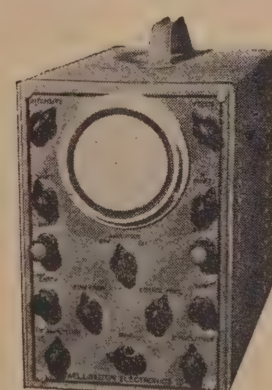

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TO THE EDITOR

Pulse Modulation

Sir,—In the interest of your readers, may I be permitted to draw your attention to some misconceptions expressed in the article entitled "Pulse Modulation and All That" which has appeared in your issue of February, 1949. The writer seems to have become a victim of a widely-held fallacy concerning the use of the pulse method in Radar. It is stated "that, in order to generate the enormous transmitted power outputs that were required at V.H.F. in order that the range of the system should be great enough, pulse modulation was essential" and further on it is pointed out that pulses of the same peak power as used for C.W. transmission are equally well received.

Whilst there can be no doubt that a reduction in duty cycle reduces the average power supplied to the transmitter, we must not lose sight of the fact that, in order to receive a short pulse without distortion, the bandwidth of frequency acceptance of our receiver has to be correspondingly increased. It follows, that the shorter the pulses the wider the receiver bandwidth necessary.

What matters in reception is not the signal strength at a given point but the signal-to-noise ratio at the receiver. As is well known, the noise-power of a receiver is proportional to its bandwidth and it may be demonstrated that the possible gain in peak power when supplying to the pulse all the power used for the transmission of a C.W. signal is just compensated by the increase in the noise with which the signal has to contend. Hence, the performance of a Radar system with regard to the range on a particular target is determined, other things such as pulse repetition rate and wavelength being equal, by the average power and not the peak power of the pulse generator. Short pulses in Radar are merely used to get the echo clear from the initial pulse and it is obvious that the pulse length employed has to be the shorter the closer the range of the reflecting target to be observed.

K. KREIELSHEIMER,
Auckland University College.

Visit of Leading Australian Radio Executive

A recent event of great importance to the radio trade was the visit to New Zealand of Mr. A. P. Hosking, Manager of the Amalgamated Wireless Valve Co. Pty. Ltd., Sydney.

A combined cocktail party and lecture evening was held at the Royal Oak Hotel, Wellington, on Thursday, 16th December, at which Mr. Hosking welcomed approximately 100 guests from all branches of the radio trade. In addition to a very interesting and informative lecture, which dealt with the growth and development of valve manufacture in Australia, Mr. Hosking had brought with him documentary evidence in the form of three excellent 16 m.m. sound films.

The first, "They're called Electrons," set back the clock some 40-odd years to the time when Dr. J. A. Fleming discovered that by employing the emission of electrons from heated metals within a vacuum, it was possible to conduct radio frequency currents. This was followed by a simple theoretical explanation of the flow of electrons from cathode to anode and the introduction of the third element known as the grid, thus heralding the simple triode valve which must be credited to Dr. de Forrest.

By progressive stages one witnessed step by step the advancement that had been made in the art right up to the release of the modern and complicated triode heptode of to-day.

The second and third films, entitled respectively "Radiotrons in the Making" and "A Miniaturisation," gave a visual portrayal of factory processes involved in a modern valve works such as the Amalgamated Wireless Valve Company's Ashfield plant, the subject being interestingly introduced by taking an exploratory journey through the valve works, having as one's motive the discovery of the source governing electronic flow; in other words, the power behind the gun.

Whilst on the subject of manufacture, Mr. Hosking paid due credit to his parent company, Amalgamated Wireless (Australasia) Ltd., for pioneering valve manufacture as far back as 1919, five years before broadcasting commenced.

With the growing expansion of the market, in 1932, A.W.A., in collaboration with its overseas associates, formed the present company now known as Amalgamated Wireless Valve Co. Pty. Ltd. The tie-up with its shareholding companies, Messrs. Radio Corporation of America, International General Electric, and the Westinghouse Company, provided, among many other features, the full and complete exchange of all patented inventions, a wealth of manufacturing information, and the continuous benefits of all research work carried on in the respective laboratories.

The growth of the valve company in its short span of 15 years of life had really been phenomenal, for starting from scratch in 1933 with a factory area of 15,000 square feet, a staff complement of 30 operatives, and a range of four types, the output after twelve months' operation reached approximately 300,000 valves; since when the expansion had been in keeping with market needs. By 1936, three years following the commencement of operations, the factory area had more than doubled itself, whilst the number of trained operatives had increased to 300, with a range of 50-odd valve types, and an output just short of one million valves per annum.

During the war, the company, in common with its parent, Amalgamated Wireless (Australasia) Ltd., made available its complete resources and concentrated all endeavours to meet the growing and exacting demands of the Armed Forces. The job it did may be judged from the knowledge that its contribution to Great Britain and her allies amounted to between five and six million tubes which were used by the Allied Forces in combat equipment as far afield as Egypt, India, Malaya, New Guinea, and the Far East.

Biographical

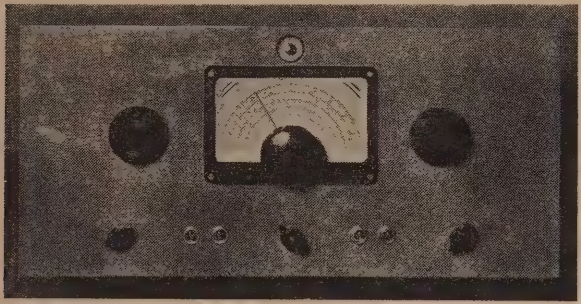
Some of the guests at the cocktail party. From left to right: Mr. J. Norman and Mr. N. Palmer of the engineering staff of the N.Z.B.S., Mr. D. Jenkins, Civil Aviation, and Messrs. W. D. Foster and C. Roser of "Radio and Electronics."

Mr. A. P. Hosking, Manager, Amalgamated Wireless Valve Co. Pty. Ltd., took over control from its inception and has seen it develop to its present importance. Prior to organizing valve company activities, he was Sales Manager to the parent company, Amalgamated Wireless (Australasia) Ltd. Mr. Hosking was in the 1914-19 war, having served from late August, 1914, to November, 1915, with the South African Forces and from 1916 to 1921 with the R.A.N.R.S., and was also with the Australian Military Forces from 1941 to 1943 serving as Adjutant to one of the Australian units.

The "Junior" Communications Receiver

Valve Line-up—*continued*

If conditions are good, and extreme selectivity is not wanted, the 100 kc/sec. stage is at a slight disadvantage, because the side-band cutting associated with high selectivity has to be put up with. This disadvantage, however, is slight compared with the advantages conferred by the high selectivity, which is yet not so great as to render speech unintelligible. Those who have not handled a receiver with very good selectivity have no conception of the way in which signals can be copied that would be quite inaudible on a broader receiver, owing either to the increased noise that the extra bandwidth brings, or to adjacent-channel interference.



Front panel view of the set. The lower row of controls, from left to right, are:—Manual gain, stand-by switch, A.V.C. long-time-constant switch, oscillator band-set, noise-limiter, on/off switch, B.F.O. on/off switch, and A.F. gain control. Above are the 1st detector tuning and the B.F.O. tuning knobs on either side of the main dial.

Why 100 kc/sec.?

In the amateur transmitting world, there has recently been a considerable recrudescence of interest in the highly selective set, following articles describing the use of double-conversion receivers, made by using war surplus receivers as the second I.F. channel. These receivers had an I.F. frequency in the neighbourhood of 85 kc/sec., and could easily be modified to receive the usual 465 kc/sec. I.F. of a normal receiver. This arrangement was described under the name of the "Q-5er," and its undoubted virtues were very adequately extolled in *Q.S.T.* After this, many amateurs tried the scheme, and found it as good or better than the claims made for it by the original author. Consequently, there appears to be a great deal of discussion about shifting to a second I.F. of 85 kc/sec. Many of those who wish to do so are "stumped" by the fact that the said war-surplus receivers are unobtainable, or else go to great trouble to acquire one, in order to put the low-I.F. idea into practice.

While this is an excellent thing to do, many people seem to be under the impression that there is some magic in the figure of 85 kc/sec., and will have none of any suggestions that since 100 kc/sec. I.F. transformers are readily available on the local market, it would be better policy to build a "Q-5er" unit for themselves, but with a 100 kc/sec. I.F. Now this is a very mistaken notion indeed, and very often the reason given is that if 100 kc/sec. is selective, then 85 must be even more so. This reasoning is perfectly correct, but the debatable point is: "Is the extra selectivity of 85, compared with 100 kc/sec., worth going to a lot of trouble to get?" In our opinion it is not. With only one stage of 100 kc/sec. I.F., the selectivity is so high that it is essential to limit the low audio frequency response of the receiver, so that speech will not be unintelligible. Eighty-five, as against 100, might be preferable for the man who is interested solely in C.W. reception, where any increase of selectivity at all is a good thing, but for general purpose use where both phone and C.W. have to be catered for in the same receiver, it is exceedingly doubtful whether the 85 is any better than 100. To our way of thinking, it is not quite so good, as phone reception is of very little use unless it can be understood, however free it may be from noise or heterodynes!

There are other reasons, too, why 100 kc/sec. is preferable to 85, and these are connected with the ease of manufacturing I.F. transformers for both frequencies. Suffice it to say that were the manufacturers to turn out transformers for 85 kc/sec., they would be considerably more expensive than the 100 kc/sec. ones.

The real point about 100 kc/sec. for the second I.F. is simply that it is a much lower frequency than anything used for domestic sets, or, for that matter, in communications receivers which do not use the double superhet. principle, and therefore enables a vast increase in selectivity to be obtained without the use of special circuits of any kind. This can be seen by an examination of the circuit of the present receiver.

Remainder of the Set

So far, our description has taken us as far as V_4, the 100 kc/sec. amplifier. The second detector is V_5, a 6H6, which is used also as the A.V.C. rectifier and a noise limiter. Following this is a conventional audio amplifier consisting of a 6J7 and a 6V6 output stage. The rectifier is an 80 or 5Y3, which completes the line-up except for the beat frequency oscillator and the magic eye tuning indicator, which are shown on separate diagrams.

Circuit in Detail

Although the description given so far shows that the set consists of a fairly formidable array of valves, this need not deter the intending builder if he has not previously tackled anything so ambitious. The main reason for this is that to an even greater extent than usual the amplification takes place at fixed frequencies. Further, there is only a single stage working on any one frequency. The first detector, or mixer, has its grid circuit tuned to signal frequency, and this is the sole circuit on this frequency. There is thus no possibility of oscillation occurring at signal frequencies, unless the mixer circuit should be regenerative, which it certainly is not. There is a single stage of amplification on 1600 kc/sec., a second frequency converter (which itself can hardly be troubled with regeneration), and finally the 100 kc/sec. stage. We thus have no more than two plate circuits tuned to the same frequency, so that even if common coupling does occur through the power supply, it cannot readily produce regeneration and instability. Since the most prolific source of this kind of trouble is feedback over two or more stages, the valve and circuit line-up alone removes it. The only remaining possibility for instability is that individual stages may sometimes fail to "sit down," but with a good lay-out, such as the one recommended, this is most unlikely, and would only occur if the stages were wired in a very untidy fashion. A feature of the mechanical design is that there is ample

chassis room in all parts of the circuit, and another is the way in which the lay-out after the first mixer and oscillator follows the progression of the circuit.

Although the circuit has been described as the "Junior" Communications Receiver, this does not mean that it is not strictly modern in design, if we exclude a return to plug-in coils—which are as efficient an arrangement as ever. The first mixer circuit in particular calls for special mention. Although it uses a triode—one section of a 6J6 (or an ECC91, which is electrically the same thing)—this is worked under different conditions from the circuit which has become known in this country as the infinite-impedance mixer. In the latter, the conversion gain is so low as to be almost non-existent, owing to the very high value of cathode resistor employed. This has certain advantages, but there are even greater advantages in a triode mixer which uses a high-g_m valve, and a much lower value of cathode resistor.

Sometimes the infinite-impedance mixer is a little difficult to "sit down," owing to the very high effective plate resistance of the triode under the conditions of operation in that circuit. Tests have shown that the plate resistance of the infinite impedance mixer is, if anything, higher than that of an R.F. pentode used as a mixer, which rather gives the lie to those who think that the triode must damp the I.F. circuit in its plate lead rather heavily! However, that is somewhat beside the point at present, and readers will want to know why we have decided to alter the operating conditions in this way when we have for so long advocated the infinite-impedance circuit.

The main reason is that this circuit does not appear to be suited to high-g_m valves. This is probably connected with the well-known fact that a cathode follower becomes regenerative at frequencies where the stray capacity between the cathode terminal and earth becomes appreciable. With a low-g_m valve, a larger cathode-earth capacity can be tolerated, simply because the gain *in the valve itself* is lower, owing to the lower mutual conductance. It seems to be a general rule, too (which bears out this theory), that the higher the mutual conductance of a valve, the lower the value of un-bypassed cathode resistance that it will tolerate before becoming inherently regenerative.

Another reason, that will appeal to many readers, is that the triode mixer need not have zero conversion gain when used with a comparatively low cathode resistor. In the appropriate circuits, a triode mixer can have a substantial conversion gain, and experiments have shown that the 6J6 circuit used here produces very many more times the conversion gain of the same arrangement with a very high cathode resistor.

The circuit used here is, as far as we know, a new one for a superheterodyne mixer, though it has obvious affinities to one developed by Sziklai and Schroeder, and reported in the Proc. I.R.E. The plates are paralleled, to form a single plate in whose circuit the I.F. transformer is connected. An unbypassed cathode resistor, common to both units, since separate cathodes do not exist, allows the right-hand unit in the diagram to act as a cathode-follower buffer, following the oscillator, so that its output, at the common cathode, is applied to the grid circuit of the left-hand section of the valve. At the same time, of course, the oscillator injection grid modulates the current to the common plate, at oscillator frequency. Because the left-hand section of the valve has oscillator voltage fed, effectively, to its cathode, this section, too, modulates the current to the common plate, in phase with that caused by the injection grid. As a result, the modulation of the space current by the oscillator is more effective than if the plates were separated so that the right-hand section acted as a genuine cathode follower by having its plate directly connected to H.T., and therefore to earth as far as I.F. is concerned.

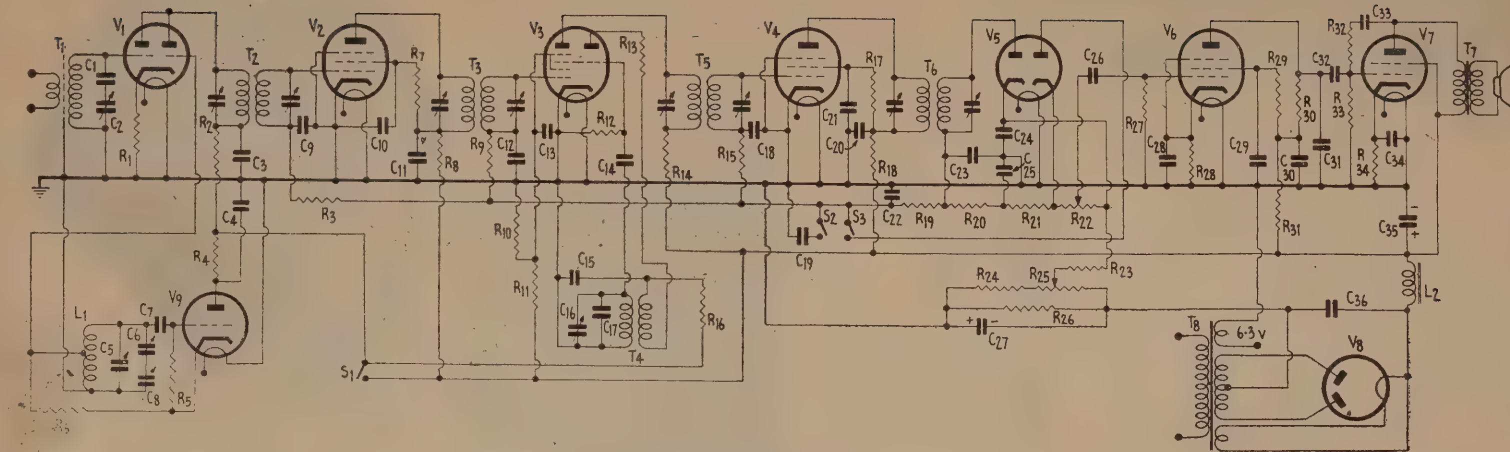
In any receiver, and especially in a high-gain one such as this, it is desirable that the overall gain should be as constant as possible over each wave-band, and also from one band to the next. In conventional receivers, a frequent contributory cause of gain variation is that the oscillator output changes rather widely at different parts of the one band. Here, we have used an oscillator circuit which gives a remarkably constant output from one end of each band to the other. It is a modification of the well-known grounded-plate triode oscillator, in which regeneration is provided by tapping the cathode directly on to the tuned circuit, which is connected from grid to earth. In this circuit, it is usual to find the cathode tapped about a third of the way up the tuned circuit, and to find no resistance connected between the tapping point and the cathode terminal. Here, however, the tapping point is exactly at the centre of the coil, and the degree of feedback is further limited by the insertion of a 1000-ohm cathode resistor between the coil and the cathode. Thus, the valve is partially cathode biased, and biased partially also by the ordinary grid-leak method. The result is an oscillator not only with less output than usual, but with virtually no variation of output over each wave-band. This can readily be demonstrated by putting a microammeter in series with the grid-leak, and observing the grid current as the tuning is varied. It will be found that with the cathode tap exactly on the electrical centre of the coil, the variation is nil, but with the tap to one side or the other of this point, the output can be made to rise at either end of the tuning range.

The first I.F. amplifier, on 1600 kc/sec., uses a 6BA6, for reasons which were explained earlier in this article. Another reason for the use of this valve is that it is possible to apply A.V.C. to it; this cannot easily be done to many other high-g_m tubes, such as the 6AC7 and the EF50, which makes them difficult to apply to receivers which must have A.V.C. The fact that the 6BA6 is a miniature is purely incidental as far as this set is concerned. A noteworthy point about the 6BA6 circuit is that it has no cathode resistor. Nor, for that matter, have the ECH35 or the EF39, but in the case of the 6BA6, there is a special point about this which is worth knowing when it comes to using it in other circuits. It is this: The 6BA6, for some reason not quite understood to the writer, does not take kindly to resistance in its cathode circuit. In the valve data books the recommended cathode resistor is very small—only 68 ohms—so that it is particularly difficult to bypass this properly. This may have something to do with the problem, which seems most likely, since on a number of occasions on which a 6BA6 has been constructed it has been found that the utmost difficulty occurred in keeping the stage stable as long as cathode resistor biasing was used. As soon as the cathode resistor was removed, the instability ceased. This practice is confirmed by Messrs. A.W.V., who, in circuits for the 6BA6, have so far shown it operated under zero-bias conditions.

Here, however, the minimum bias is not zero, since all the R.F. valves, with the exception of the 6J6, which is not controlled, are biased from a back-bias system, which gives a minimum of — 3 volts. The system used will be described later.

The circuits of the ECH35 second mixer and the EF39 second I.F. amplifier are quite conventional. The oscillator section of the ECH35 has to work on a frequency of 1500 kc/sec. so as to produce a 100 kc/sec.

(Continued on page 35.)



Component List

R_1, R_{13}, 3k.
R_2, R_8, R_{14}, R_{18}, 2,500 ohms.
R_3, R_9, R_{15}, R_{17}, R_{20}, 100k.
R_4, R_5, R_{12}, R_{16}, R_{31}, 50k.
R_6, R_{23}, 1,000 ohms.
R_7, R_{10}, 35k.
R_{11}, 25k.
R_{19}, 1 meg.
R_{21}, R_{27}, R_{29}, R_{30}, 500k.
R_{22}, 500k. pot.
R_{24}, 10k.
R_{25}, 25k. pot.
R_{26}, R_{34}, 250 ohms.
R_{28}, 500 ohms.
R_{32}, 2 meg.
R_{33}, 250k.
T_1, aerial coil (see text).
T_2, T_3, 1,600 kc/sec. I.F. transformers.
T_4, 1,500 kc/sec. osc. coil (see text).
T_5, T_6, 100 kc/sec. I.F. transformers.
T_7, output transformer.
T_8, power transformer, 280v. a side.
L_1, osc. coil (see text).
L_2, smoothing choke, 80 m.a.
C_1, 200 $\mu\mu$f. silvered mica.
C_2, 100 $\mu\mu$f. max. variable.
C_3, C_{10}, C_{11}, C_{13}, C_{18}, C_{20}, C_{21}, C_{33}, 0.05 μf.
C_4, C_{29}, 0.1 μf.
C_5, 100 $\mu\mu$f. max. variable.
C_6, C_{16}, 3-30 $\mu\mu$f. Philips trimmer.
C_7, 100 $\mu\mu$f. silvered mica.
C_8, 50 $\mu\mu$f. max. variable.
C_9, C_{12}, 0.002 μf.
C_{14}, 50 $\mu\mu$f. mica.
C_{15}, C_{22}, 0.02 μf.
C_{17}, 100 $\mu\mu$f. mica.
C_{19}, 0.5 μf.
C_{23}, C_{25}, C_{31}, 250 $\mu\mu$f. mica.
C_{24}, C_{28}, C_{34}, 25 μf. 25v. electro.
C_{26}, 0.001 mica.
C_{27}, 100 μf. 50v. electro.
C_{30}, 8μf. 450v. electro.
C_{32}, 0.005 μf.
C_{35}, C_{36}, 16 μf. 450v. electro.
S_1, S.P.S.T. stand-by.
S_2, S.P.S.T. A.V.C. time-constant.
S_3, S.P.S.T. noise-limiter on/off.
V_1, 6J6 or ECC91.
V_2, 6BA6.
V_3, ECH35 or 6K8.
V_4, EF39 or 6K7.
V_5, 6H6 or EB34.
V_6, 6J7.
V_7, 6V6.
V_8, 80 or 5Y3.
V_9, 6C5 or 6J5.

QUESTIONS and ANSWERS

Identifying Some Spurious Signals

"A.E.R." writes from R.M.S. *Akaroa* as follows:—

"While in Wellington before Christmas, I found that I could pick up 2ZB when my receiver was tuned to 1.95 mc/sec., at a strength comparable with the normal transmission, and apparently with no difference in quality. Now, here in Auckland, I find that 1YA, on 750 kc/sec., comes in also at 1.5 mc/sec., though in this case with much reduced strength. My receiver, the recently-introduced Eddystone 670, has an I.F. of 465 kc/sec., and one R.F. stage, which seems to preclude the possibility of these signals being any kind of image. Perhaps you have come across this kind of effect before, and can tell me if my idea is correct, or if there is some other explanation. I have come to the conclusion that they must be the second harmonics."

The signals mentioned by A.E.R. do appear to be the second harmonics of the stations concerned. There is no kind of image interference which can cause signals to appear on the dial at the second harmonic frequency of the transmission proper, and the only likely explanation is that the signals are actual harmonic radiation by the transmitters concerned. In the case of 2ZB, the distance air-line to the harbour at Wellington is only a matter of a mile or so, so that even if the harmonic radiated had a power of only a few watts, a very strong signal could be expected. In addition, the second harmonic of 2ZB is not normally received on ordinary sets, because these do not cover the frequency range on which this is to be found. The behaviour of the second harmonic of 1YA is more in line with what one would expect, however, as broadcast stations are required by regulation to keep the amplitude of their harmonic radiation down to a stated very small figure.

A Comprehensive Exciter Unit

"P.S.S.," Wigram, writes as follows:—

"For some time past I have been experimenting with a pair of paralleled 807's, and am convinced that they should operate quite well right through to 50 mc/sec.

"I therefore decided to try and design an all-band transmitter with 100 watts input. It had to be compact (external power pack, but modulators included) and capable of operating on plate-modulated A.M., N.F.M., P.M., and C.W., either crystal or V.F.O. controlled. I worked out an exciter which would do all this, on all bands, and discovered that I had a tremendous array of knobs to tune every time the frequency was changed. In order to get over this difficulty, I considered using a stable V.F.O. (or crystal) with a distorted, harmonic generating waveform, followed by a low-level harmonic selector, and straight amplifiers to drive the 807's. This would be far easier to gang, and would be far more economical. The only trouble is to find a V.F.O. stable enough to do the job, and yet turning out enough higher order harmonics. I was hoping to use a crystal oscillator on 7 mc/sec., beating against a Clapp oscillator on 5-5.5 mc/sec., to give a basic output of 1.5-2.0 mc/sec. My question is this: would there be some way of adjusting either oscillator to generate a highly distorted wave? The crystal oscillator could be reactance modulated to give phase modulation, while the V.F.O. could be modulated similarly to give frequency modulation. Oscillator or buffer keying could be used for C.W., and the straight amplifier and possibly the V.F.O. could be ganged. Could you therefore make any comments on this proposal, and suggest alternative types of harmonic generator?"

P.S.S.'s scheme is an interesting one, and in the main, not difficult to put into practice. We do not think it is practicable to generate the harmonics directly in the oscillators, or in the mixer. The reason for this is that for the latter to produce large quantities of harmonics, it is necessary for both oscillators themselves to be rich in harmonics. This is easy enough as far as the crystal oscillator is concerned, but in a V.F.O. the production of harmonics conflicts with the requirement of high stability. Thus, it is recommended that the harmonic generation be done after the mixer. This means that the latter would be tuned to the difference frequency between the two oscillators, and that the best results would be gained by having either a separate knob for this circuit, or else by having a broad band circuit tuned to the centre of the band, i.e., to 1.75 mc/sec. Even if it is decided to try and track the tuning of the mixer output with the variable oscillator, this should not be too difficult, since the tuning range is so narrow. The next step would be to introduce a distorting amplifier, with an untuned plate circuit. This could be a 6AC7, EF50, or similar tube, and should be operated with a low value of plate resistor—say, about 2,000 ohms—low screen voltage, and zero grid bias. Under these conditions, the harmonic output will be quite good, but some experiment would be necessary to find out whether there was sufficient harmonic output above about 20 mc/sec., and it may be found desirable to have a second stage, similar in all respects to the first, in cascade with it. As for the ganged "straight" amplifiers, these will have to be numerous enough for the last to run Class C, and to produce appreciable power output for driving the 807's. This will not be an easy problem, as stability will have to be very good, with no chance whatever of the straight amplifiers breaking into oscillation. One difficulty will be that the high-frequency end of the range will need more amplification than the low-frequency end, and off-hand we can suggest only one way out of this. It is to use the first stage only of the untuned distorting amplifier for low frequencies, and the two stages in cascade for the higher ones.

A further source of trouble suggests itself with regard to the frequency modulation of the variable oscillator. The so-called Clapp circuit is possibly the best yet devised for high-stability oscillators, but if a reactance modulator is connected across it, the stability would be determined, not by the very stable Clapp circuit, but by the (in comparison) very unstable circuit of the reactance modulator. However, since a deal of frequency multiplication will necessarily be used before reaching any of the bands on which wide-band F.M. can be used (if this is wanted) it should be possible to connect the modulator across the cathode circuit of the oscillator, thereby reducing the effect of variations in the constants of the modulator in the same way as the circuit reduces the effects of variable electrode voltages and tube capacities in the case of the oscillator valve itself. In any case, the frequency calibration of the variable oscillator should not be carried out until the reactance modulator has been connected, and is working normally, except for the absence of a modulating signal.

Some Oscilloscope Problems

"C.S.L.K.," Christchurch, writes: "I have a query regarding the oscilloscope I am building, and as I have already started, I would appreciate a reply as early as convenient for you.

"It concerns the connection of a 'Z' axis amplifier, or, as you call it, a brilliance modulating tube, to a 'scope which is intended to have a black-out tube. The circuit I am using is exactly the same as your 'Unit Construc-

tion' circuit. From R_{50}, in the plate circuit of V_6, I intend to feed a pulse to a black-out tube similar to the one used in your first oscilloscope circuit (May, 1946, issue *et seq.*) but I wish to know how to connect the output of a single pentode, as Z amplifier. Perhaps it will not be possible to use a 6SN7 as in your circuit. If possible, I would like to preserve your black-out circuit, and use as Z amplifier the circuit for the X amplifier from *Radio and Hobbies*, February, 1948, issue, page 35.

"I have two more queries as well. (1) What is a suitable frequency at which to run an electronic switch, for obtaining two distinct pictures on the screen of the 'scope? (2) Can astigmatism control be applied to the sweep circuit described in the November, 1948, issue of *Radio and Electronics?*"

Taking these questions in order:—We are not quite sure from the way this question is put whether the facility required is that of using the black-out and the Z amplifier simultaneously, or as alternatives. That is to say, if the Z amplifier is being used, the black-out tube may not be required, since in using a brilliance modulation of the trace the linear time-base is often not needed. The following suggestions therefore apply to two arrangements, one of which enables the black-out and brilliance modulation to be used simultaneously, the other enabling the same circuit, with the addition of some switching, to perform both functions as alternatives.

In the first place, it would be possible to use the pentode Z axis amplifier as the black-out phase inverter using the 6SN7 merely as a cathode follower. The arrangement would be to place a "Z input" terminal on the front panel, and also a further terminal, connected to the plate of V_6, and labelled "Black-out Out." In using the black-out, these two terminals would be bridged, and when brilliance modulation from some outside source is wanted, this link would be broken. The input potentiometer to the Z amplifier could control the amplitude of the black-out waveform, or of the brilliance modulation, according to the connection made.

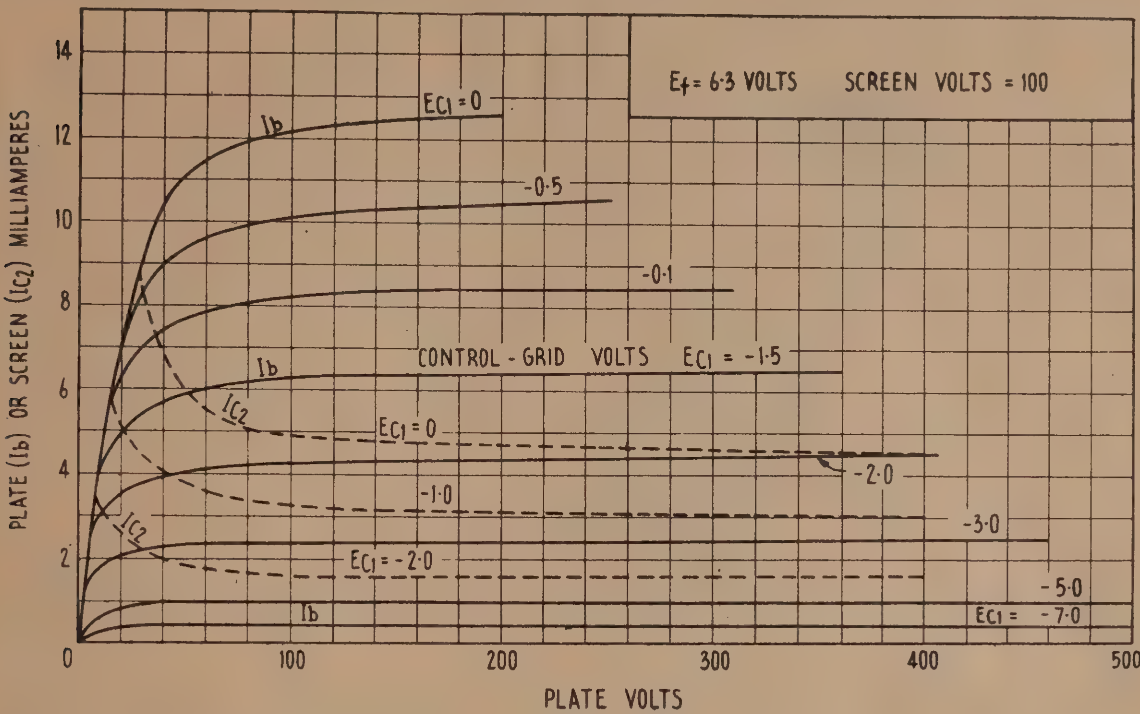
If another valve can be accommodated, the 6SN7 could be connected as a cathode follower mixer (see *Radio and Electronics*, August, 1947) and the extra valve used as the black-out phase inverter. The output of this would then feed into one of the mixing grids, while the output of the Z amplifier would feed into the other. There would be no need to switch the black-out waveform, as this would be absent when the time-base is not running. This arrangement would leave the Z amplifier solely for external use and would give the extra facility outlined above.

The frequency for an electronic switch is governed mainly by the lowest frequency that must be examined on each trace formed by the switch. Thus, if one wishes to show a complete cycle of 50 c/sec., on each trace, the switching must take place at or slower than 25 c/sec. On the other hand, there is a lower limit to the switching frequency that can be successfully used, because the oscilloscope amplifier must be able to handle a square-wave at the switching frequency with no visible distortion at all. From this point of view, a comparatively high switching rate is preferable. However, with the amplifier circuit used in the "Unit Construction Scope," recently described in our pages, and which you are using, 25 c/sec. should be quite satisfactory.

Unfortunately, it is not possible to add astigmatism controls to this circuit without a fair amount of trouble, and modification to the power supply. "C.S.L.K." seems

(Continued on page 48.)

TUBE DATA: DATA AND CHARACTERISTIC CURVES FOR THE 6SG7



The 6SG7 is a single-ended metal tube, and is a pentode with a high mutual conductance and a semi-remote cut-off. It is very useful as a high-gain R.F. or I.F. amplifier, on account of its high mutual conductance, and because of this feature it is able to provide much higher stage gain than the more ordinarily used R.F. pentodes. Unlike most high-g_m valves, notably the 6AC7 and 6AK5, it has an extended grid base, and is able to have A.V.C. placed upon it. As will be noticed from the characteristics, printed below, the grid base is not so extensive as that of the 6K7, 6U7, 6SK7, etc. As a result, care must be taken in receivers designed round this valve to see that the A.V.C. voltage applied to its control grid is not excessive. In some cases, where the receiver is not to be operated at close range from a local broadcast station, or where reception is limited to the short-wave bands, there is no need to take special precautions. If the A.V.C. voltage can rise too high, however, as it may in some locations where very strong local signals are present, it is advisable to use only one-half the available control voltage. Where the 6SG7 is used as the only or the final I.F. stage in a receiver, it is advisable to use ½ A.V.C. voltage on it in any case. The circuits used with this valve can be quite conventional except for this, however, as long as it is remembered that a high-gain stage needs better than usual shielding if it is to be stable. A cross-socket shield is strongly recommended in all cases.

Grid bias can be obtained from a cathode resistor in the normal way, and screen-grid voltage can be obtained either from a voltage divider or from H.T. through a dropping resistor. The latter method is to be preferred, as it enables the fullest use to be made of the extended cut-off feature. The suppressor-grid of the 6SG7 is internally connected to the cathode and to pin No. 3.

Base Connections

The base connections of the 6SG7 are as follows:—

Pin No. 1—Shell
Pin No. 2—Heater
Pin No. 3—Cathode
Pin No. 4—Control Grid
Pin No. 5—Cathode
Pin No. 6—Screen
Pin No. 7—Heater
Pin No. 8—Plate

Ratings

Plate Voltage	300v. max.
Screen Voltage	200v. max.
Screen Supply Voltage	300v. max.
Grid Voltage	0v. min.
Plate Dissipation	3 watts max.
Screen Dissipation	0.6 watts max.

Typical Operation

Plate Voltage	100	250	250v.
Screen Voltage	100	125	150v.
Grid Voltage	—1	—1	—2.5v.
Plate Resistance (approx.)	0.25	0.9	>1 meg.
Mutual Conductance	4.1	4.7	4.0 ma./v.
Grid Bias (for g_m of 40 μa./v.)	—11.5	—14	—17.5v.
Plate Current	8.2	11.8	9.2 ma.
Screen Current	3.2	4.4	3.4 ma.

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ELECTRONIC MUSICAL INSTRUMENTS

By C. R. LESLIE (Member of the Electronic Music Group)

PART 2

Oscillator Types—*continued*

Another popular form of oscillator is the familiar transitron. The system operates readily and is reasonably stable but is somewhat limited in pitch range for any one condenser setting, especially at the lower frequencies, in comparison with the multivibrator. However, to counterbalance this factor, the system is versatile, in that an R.C. coupled transitron can be made to produce a pure sine wave or act as a relaxation oscillator. If arrangement is made to effect top and bottom cut of the sine wave as desired we will be in a position to produce sine waves, square waves or sawtooth wave forms as required, and so widen the scope of the tone colour available. Let us consider these three aspects in turn.

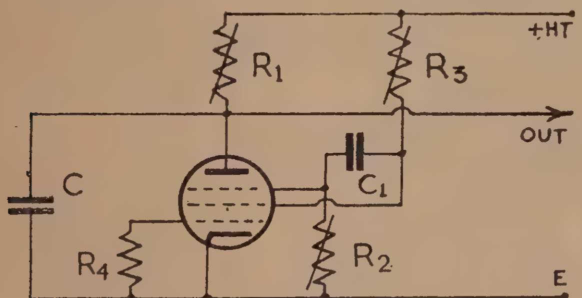

Fig. 6.

Fig. 6 gives a schematic of the normal R.C. coupled version operating as a sawtooth or relaxation oscillator. The adjustment of R_1 and R_2 controls the charging time of the "pitch" condenser C, while the adjustment of R_3 regulates the ratio of the charge and discharge time and so becomes in effect a pre-set amplitude control. R_1 may also be pre-set and adjusted to give the maximum frequency range control from R_2 which may now take the form of a specially wire-wound variable resistor as mentioned in connection with the multivibrator. The main points to watch are the choice of valve and the value of C_1, which must be considerably higher (at least ten times) than the largest value of the "pitch" condenser C, so that the impedance of C_1 at the lowest frequency is very small in comparison, otherwise the discharge of C will be seriously curtailed. The valve should be selected to have a high ratio of anode to screen current, such as a Mullard EF50. The reason for this is that on discharge of the condenser C the screen potential may rise to a high level and so accelerate the discharge time. As a rough guide to component values we give the following—though it should be realized that optimum values are best obtained by trial—R_4 is not critical and may be some 10,000 ohms; R_1 from 0.2 to 2 meg.; R_2 about 0.25 meg., and R_3 from 50,000 to 0.5 meg. according to the HT. voltage, which may be from 350 to 700 volts. The frequency of oscillation, as already mentioned, is dependent on the mutual adjustment of R_1 and R_2. In practice it would be advisable to use a separate "pot." for each condenser setting so that R_3 may remain unaltered. C_1 and R_3, once adjusted, stay put.

Fig. 7 shows a practical circuit for the production of sine waves. C_1 and C_2 together effect the frequency and hence are banked in pairs and selected to give the optimum ratio values which may vary from 0.25/1 to 10/1 and will have to be chosen by trial. The frequency is numerically equal to $1/2\pi\sqrt{R_1R_2C_1C_2}$, where $R_1 = R_3R_4/R_3 + R_4$ (i.e., the resultant value of the parallel network). The slider of R_4 determines the AMPLITUDE of oscillation while R_3 governs the

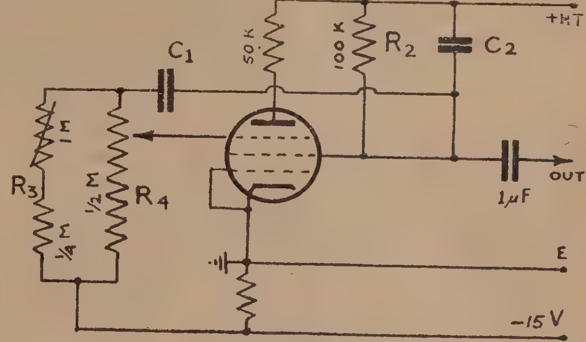

Fig. 7.

FREQUENCY. The valve should have as linear a negative characteristic as possible and this implies the use of a vari-mu type such as a 78. This rather clashes with the requirements of the R.C. sawtooth circuit above, but a reasonably good practical compromise is obtained by the use of a 6U7.

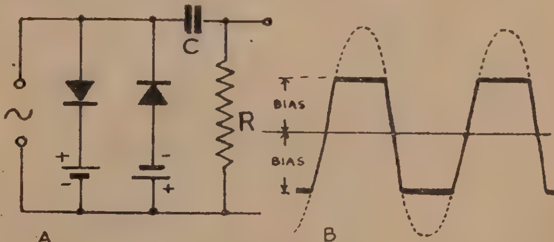

Fig. 8.

In order to effect top and bottom cut the sine wave output may be fed to a pair of biased-back metal rectifiers connected in parallel as shown in Fig. 8 (*a*). The diagram at (*b*) explains the action on the sine waveform; it will be seen that the bias gives the limiting action. The bias may be applied in the usual manner by the use of bias resistors and by-pass condensers. The condenser C is inserted as a reservoir to equalize the voltages of the harmonics and should be of such a value that its reactance at the lowest frequency is small compared with R.

It has already been mentioned that the square wave consists of odd harmonics. If even harmonics are required we can feed the sine wave output to a full wave metal rectifier system in the normal way.

Another worth while relaxation oscillator may be

constructed by the use of cold cathode Neon tubes—giving special mention to the Osglim "pea" Neon on account of its small size. Fig. 9 shows a typical circuit and its action will be readily understood. The frequency is governed by the CR constant, the value of C being kept small to use very little charging current. The admission of light has an effect on the frequency, so the Neons should be screened from light interference. Owing to their compact size and to the absence of

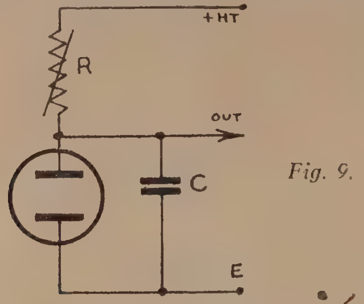

Fig. 9.

heater current the "pea" Neons lend themselves to systems where a separate oscillator is required for each note, or where separate oscillators are required for each semitone of an octave, the highest of an instrument's range, while the lower octave frequencies are obtained by frequency division. Alternatively, if care is taken in the insulation of the keying method, a Neon may be used to cover a reasonable pitch range for any one condenser setting—"hook up" experiments will quickly reveal the capabilities of any tube used.

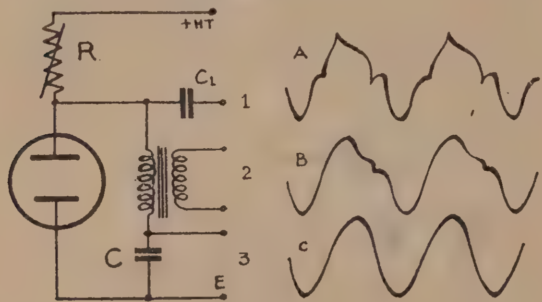

Fig. 10.

The output waveform may be varied by the manner in which it is taken. Consider the circuit of Fig. 10, where the primary of an audio transformer is shown in series with the "pitch" condenser C. The inductance and core hysteresis will affect the normal sawtooth waveform by dading harmonics and delaying the discharge with the result that if the output is taken from the coupling condenser C_1 (ten times larger than the largest value of C) we get a waveform of the type shown at (*a*). If the output is taken at 2, the waveform appears something like (*b*), and if taken at 3 it will approximate to a sine curve as at (*c*). The actual results will depend a good deal on the transformer used, those depicted here being shapes obtained by the writer using a "pea" Neon and a miniature Bulgin 1:1 intervalve L.F. transformer (Type 51). The curves at (*a*) and (*b*) approximate to a violin tone colour.

Squegging oscillators i.e., self-quenching or "blocking" oscillators) are also worthy of trial, though we will not deal with them here as they will be familiar to readers. Experiments with any type of oscillator can be quickly carried out with simple "hook ups" and connecting the outputs to the "gramo" terminals of a radio set which may also supply the heater and H.T. voltages if the necessary precautions are taken against excessive heater current by the removal of inoperative valves (I.F. and R.F. stages).

Before leaving the subject of oscillators, a word may be said about B.F.O. systems and methods of control. One such system was referred to in the July issue (Figs. 2 and 3) in connection with the Goldberg and Sohne instrument. In such cases the frequency control is effected by small changes of tuning capacity of the variable oscillator and may be achieved by the use of hand capacity in one form or another as in the above instrument. This implies the use of supersonic frequencies of 100 kc/sec. or more, so that ordinary radio coils may be used.

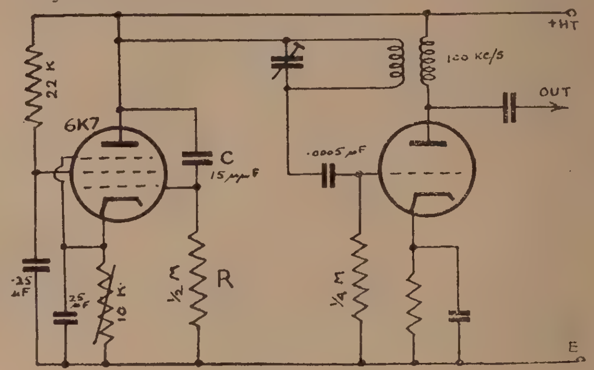

Fig. 11.

Alternatively, the tuning capacity may be varied by the use of a "reactance" valve across the tuned circuit, in which case the frequency varies according to the grid bias applied to the valve. The system opens up the possibility of using wire-wound variable resistors as referred to in connection with the multivibrator circuit. This is a convenient form of keying as it readily permits of staccato, glissando, or vibrato methods of playing. In Fig. 11 we give a schematic of the manner in which a reactance valve may be connected across the tuned circuit of a variable oscillator to serve as a variable

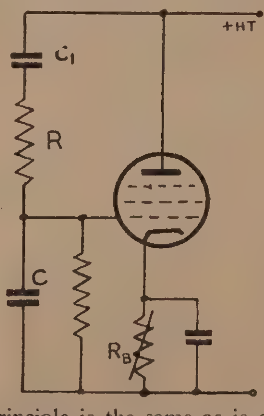

Fig. 12.

capacity. The principle is the same as is commonly used for frequency modulation (or "wobbulation") for use with oscilloscopes for lining up double humped I.F. transformers. Actual component values are best found by trial, those indicated on the diagram being a rough

starting guide. It should be remembered that the reactance of C at the operating frequency must be *very large* in comparison with R so that the anode current will lead by very nearly 90° on the applied voltage—the characteristic of condenser action.

If it is desired to vary the inductance (where this is small in over-all value) instead of the capacity, the circuit of the reactance valve may be modified as shown in Fig. 12. C_1 is not critical as it is only a blocking condenser. The criterion for successful operation is that the reactance of C at the operating frequency shall be very small in comparison to R so that the anode current will lag by very nearly 90° on the applied voltage. This inductance effect is similarly varied by alteration of the grid bias.

Lastly, as we are not necessarily intent upon purity of waveform, we are not limited to the use of sine wave oscillators in our B.F.O. system and are free to use any convenient type that we may select. This factor makes for much more elasticity in development work.

Enough has probably been said to give the reader a general idea of the possibilities open to him as regards waveform (and therefore tone colour) generation to start him off in experiments on his own account, and we can now consider some of the lines along which development is progressing.

Some Current Developments

The familiar "electric guitar" is one existing commercial development. It comprises an ordinary guitar with a pick-up arrangement under the strings. The fluctuating voltages resulting from the string vibration are amplified in a single stage orthodox amplifier contained in the body of the instrument and the output is applied to the gramophone terminals of a radio set. In effect we have a conventional instrument capable of much extended volume.

On somewhat similar lines is the amateur designed "electric guitarette." This consists of a bar of wood down which is stretched a metal string. Where the "bridge" would be normally found a headphone ear piece is located. The ear-phone is specially modified by removing the soft iron diaphragm and a substitution made from 1/16" mild steel sheet cut in the form of a cross with arms ½" wide. The thickness of the arms may be tapered by filing if desired. A ⅛" dia. central hole is drilled and countersunk on the under side to take a half-inch ⅛" screw which is held tight by means of a lock nut on the upper or outer side. A small slot is cut in the screw end to take the stretched steel string, and the earphone clamped firmly in position. The connecting leads of the earphone are plugged into the pick-up terminals of a radio set as before. Neither of these instruments can be termed strictly electronic devices.

A recent idea, developed in England by Mr. F. C. Blake, is of special interest in that it uses Neon tubes as frequency dividers, on the principle that if a synchronizing signal is impressed on the DC. potential of a Neon circuit connected up as a relaxation oscillator, the frequency of the oscillator can be locked to that signal *or a sub-multiple* of it. If the output is taken from the "earthy" electrode only the resultant divided frequency is obtained. Therefore we may commence with a thermionic oscillator for each note of the highest octave and the output from each be impressed on the D.C. potential of a series of Neon oscillators adjusted so that the natural frequency is approximately a sub-multiple of the master oscillator's fundamental. The output from each Neon is taken from across a resistor at the "earthy" end of the circuit via a keying mechanism to a subsequent amplifier—the value of the "cathode" resistor can be about 10,000 ohms. The output from the master oscillator is fed to each Neon circuit through a coupling condenser of large value. Thus the full arrangement comprises a master oscillator whose output may be fed direct to the amplifier or be keyed to a Neon oscillator tuned to half the fundamental, or to a second Neon tuned to a quarter of the fundamental, or to a third Neon tuned to a sixth and so obtain four octaves of that particular note. It is recommended that the H.T. supply to the master and divider oscillators be taken from separate sources.

It would appear from the above that the idea could be simplified by using Neons as master oscillators which could be coupled to a single amplifier whose output could be fed to the dividers, an arrangement that would reduce the heater current to one amplifier in place of the one valve per semi-tone of Mr. Blake's arrangement.

Mr. Blake is also responsible for another instrument which he calls a "Solotron." The "works" are housed in a console-like cabinet fitted with a piano-type playing manual of 25 keys, each fitted with a nickel silver contact. The waveform generator section and the output section are fed from separate power packs—both power packs and the output section (including the speaker) are located in the lower part of the cabinet while the generator unit is at the top close to the playing manual.

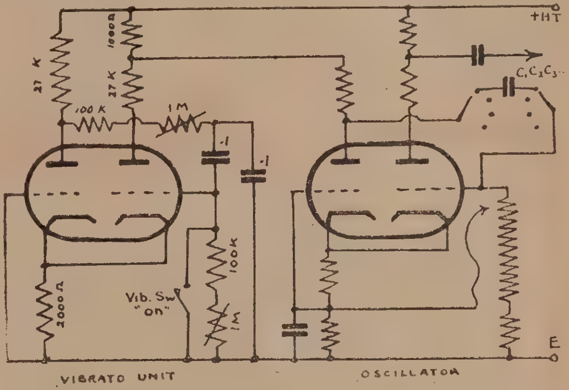

Fig. 13.

On the left side of the cabinet are the incidental controls—volume, octave range, vibrato, and tone controls, for manipulation by the left hand of the player. The generator follows the multivibrator principles already discussed with the obvious modifications required for the keying by the piano-type manual. A point of interest lies in the solution for vibrato playing. For this a separate multivibrator is used to give an oscillation of 5-15 cps. (just sub-sonic) which can be switched in to modulate the master generator from a tapping on the anode load. Fig. 13 gives a schematic of the general idea.

The output from the master oscillator is fed to a conventional 6J5 buffer amplifier, in the plate circuit of which the tone control or "formant" circuits are connected, and thence via a second 6J5 audio stage to the output valve and speaker in the usual way. The tone control section is ingeniously made up from an ordinary R.F. choke in series with the secondary of a multi-ratio output transformer, the output from the 6J5 buffer valve being connected to the junction of the R.F. and A.F. chokes. The tappings on the A.F. choke are taken to earth via condensers and switches as shown in Fig. 14. The actual condenser values are best found by trial to suit the particular output transformer used, but will normally lie between .005 μf. and .1 μf. The switch

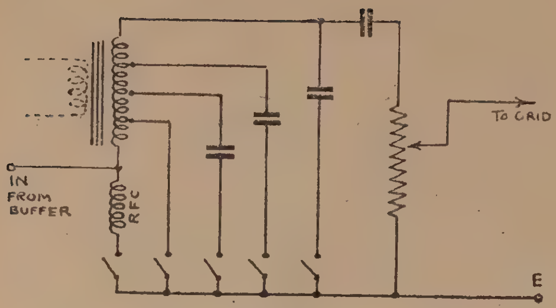

Fig. 14.

should not be of the noisy "clicker" type for obvious reasons.

Development work is also proceeding in connection with various types of electronic organs, but we have included no word of these as the purpose of these articles is limited by "simple" instruments of the single voice or melodic type.

Conclusion

For those that may desire to "have a stab" at this field of electronics we would advise that a start be made with the multivibrator generator in simple "hook up" form for plugging into the pick-up terminals of a radio set as already outlined, for by this means the latent possibilities of electronic music will be quickly manifested, and we feel confident that once a practical grip of the general idea has been obtained the experimenter will find that he will not be content until he has evolved something new and worthwhile. Like most innovations, this branch of the science only needs a leader with a successful result to show to launch a widespread field of enthusiastic endeavour—and then real and startling advances can be expected.

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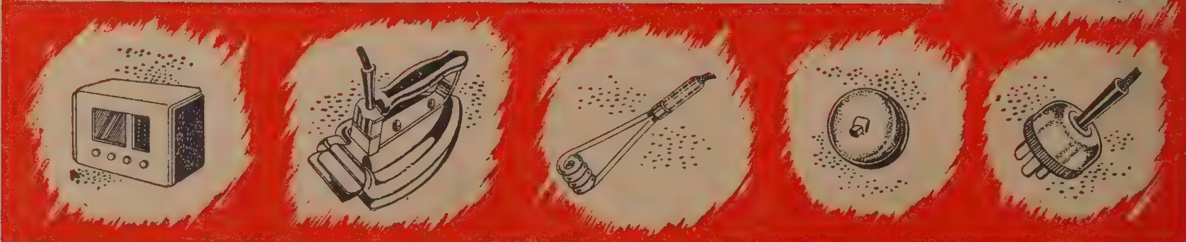

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Recording and reproduction of sound. Part 17. The decibel. Definition, use, and calculation.
—**Radio News (U.S.A.), July, 1948, p. 52.**

Electric power required for sound systems. Charts and data relating acoustic levels required, and electric power capabilities for sound systems intended for indoor and outdoor areas.
—**Service (U.S.A.), September, 1948, p. 12.**

Dynamic noise-suppressors. Short article by H. H. Scott, in which noise-reducing systems for recording work are classified and discussed. Gate circuits, l.f. and h.f. described briefly; use of reactance valves referred to.
—**Service (U.S.A.), September, 1948, p. 16.**

ANTENNAE AND TRANSMISSION LINES:

H.F. T.V. antenna installations. Details of antennae and installation procedure intended to assist U.S. servicemen in resolving practical problems.
—**Service (U.S.A.), September, 1948, p. 10.**

Ring aerial systems. (See "Radio and Electronics" Abstracts, August, 1948, p. 26.) Mathematical determination of minimum number of aerials required in a phased ring and in a concentric ring-aerial system.
—**Wireless Engineer (Eng.), October, 1948, p. 308.**

New principle in two-band rotary beam design. Dual-band operation with parasitic type four-element antenna to provide maximum efficiency when frequencies harmonically related at a frequency ratio of 1:2(e.g., 14 mc. and 28 mc.). No switching required. Details of impedance matching networks.
—**QST (U.S.A.), October, 1948, p. 13.**

A lightweight 14 mc. four-element beam. Details of construction of a close-spaced parasitic beam.
—**QST (U.S.A.), November, 1948, p. 18.**

The "Quad" antenna. Description of antenna for 28 mc. band (amateur). Antenna is quadrangular in shape. Popular version consists of two-turn loop, a quarter wavelength per side, as driven element and a duplicate as a reflector.
—**QST (U.S.A., November, 1948, p. 40.**

About antennae for 80-meter mobile. Description of several antennae suitable for 80-metre mobile use.
—**QST (U.S.A.), November, 1948, p. 42.**

CIRCUITS AND CIRCUIT ELEMENTS:

9kc/s. whistle filter. Circuit of a narrow-band rejection filter to attenuate the 9 kc. whistle caused by adjacent carrier beat in a receiver designed to accept and reproduce modulation frequencies up to 12 or 14 kc. Circuit consists basically of a bridge network of which the detector is an integral part.
—**Electronic Engineering (Eng.), October, 1948, p. 320.**

Miller integrator. Part 3 (concluding). The Sanatron circuit used as a triggered time-base generator of delayed pulse or dividing circuit. Description of operation, and other uses for circuit. The Phantastron, a single-valve circuit, its operation and application. Advantages and disadvantages of the Phantastron outlined. Article also deals severally with the use of differentiating pulse transformers and generation of other than linear waveforms.
—**Electronic Engineering (Eng.), October, 1948, p. 325.**

Gate circuits. Discussion of operation and relative merits of two-gate circuits: (1) A simple pentode circuit; and (2) a cathode-coupled circuit.
—**Wireless World (Eng.), November, 1948, p. 403.**

Stabilized power supplies. Part 2. Circuit of a 200-400-volt. 100 ma. stabilized power supply. Details of subsequent modifications by way of refinement.
—**Wireless World (Eng.), November, 1948, p. 415.**

V.H.F. valves and circuits. Negative-grid valves; their adaptation to circuits in which they operate. Common-grid earthed-anode circuits for use with disc-seal triodes and specifically mentioned English valves. Multi-valve oscillators, negative-grid amplifiers using common-grid, earthed-grid circuit. Method of overcoming difficulties in use of common-cathode in coaxial line circuits by use of everted triodes and tetrodes in which anode is innermost electrode and cathode is on outside.
—**Wireless Engineer (Eng.), October, 1948, p. 315.**

The Clapp high-stability circuit. Operation of oscillator circuit and differentiation between it and earlier circuit to which it had been likened. (A low-C electron-coupled oscillator. QST, November, 1941.)—**QST (U.S.A., October, 1948, p. 45.**

FREQUENCY MODULATION:

New trends in receiver design. Part 2. Various U.S. manufacturers' designs for tuning and input systems. Types discussed and illustrated are permeability-tuned, tuned transmission line, and parallel tuned lines.
—**Radio News (U.S.A.), July, 1948, p. 38.**

The reactance modulator. Simple explanation of operation of capacitive-change type of circuit for reactance modulator, as used in F.M. receivers and sweep generators.
—**Service (U.S.A.), September, 1948, p. 21.**

Serrasoid F.M. modulator. Circuit and mode of operation of an improved four-valve phase-shift type of modulator for F.M. broadcasting. Of particular value in relay and chain broadcasting on account of low noise background and low value of distortion. Modulator consists of crystal controlled pentode valve, a double-triode operating as a clipper cathode-follower, a double-triode as a saw-tooth generator-bootstrap cathode-follower, and, finally, a double-triode for F.M. pulse output. These valves followed by frequency multipliers with anode loads resonant at the various harmonics. Discussion of possible variations to circuit, performance, and means for increasing the total phase shift.—**Electronics (U.S.A.), October, 1948, p. 72.**

Improving F.M. transmission techniques. Circuit and construction of an N.F.M. adapter for amateur use, incorporating speech clipping and filtering.
—**QST (U.S.A.), November, 1948, p. 21.**

MATERIALS AND SUBSIDIARY TECHNIQUES:

Selecting components for broadcast receivers. Article of interest to manufacturers, giving details of methods for testing components to decide their suitability for use in radio and television receivers. Tests are classified under three headings: (1) Mechanical, (2) electrical, and (3) chemical. Circuits given for unit to test volume controls for noise, contact resistance, and insulation resistance respectively; also for a frequency drift recorder. Details of mechanical testing of tuning controls, variable resistors, switches, etc. Particulars of suitable chemical tests.
—**Electronic Engineering (Eng.), October, 1948, p. 307.**

The dry voltaic pile. Details of a Zamboni pile developed during the last war to provide a voltage between 2,000-4,000 at less than 10-9 amperes for use with image converter tube of infra-red telescope. Composition of cell described.
—**Electronic Engineering (Eng.), October, 1948, p. 317.**

MEASUREMENTS AND TEST GEAR:

Simple shutter-speed meter. Circuit and construction of a compact unit for measuring camera-shutter speeds. Uses a type 929 photo-tube.—**Radio News (U.S.A.), July, 1948, p. 58.**

A compact linear diode V.T.V.M. Simple unit employing shunt diode circuit, with type 1A3 h.f. diode, a cathode-type dry-cell valve. Unit encased in standard 3-inch, sloping front meter box. May be used as a general purpose A.C. voltmeter with wide frequency range. Special purposes for which unit may be used include taking of measurements requiring A.C. voltmeter having both input terminals above ground, and which is isolated from power line. Unit also useful for taking R.F. readings across transmission lines, for A.F. voltage measurements in audio amplifiers and modulators when points are above ground.
—**Radio News (U.S.A.), July, 1948, p. 40.**

Serviceman's portable test unit. Details for construction of unit containing test P.M. speaker, a tapped resistor, six test condensers, and an outlet socket for connecting a soldering iron or valve tester. Enables simple tests to be made of components suspected of faults. Suitable for repair work in customers' homes.—**Radio News (U.S.A.), July, 1948, p. 41.**

Low-cost all-wave signal generator. Simple unit to cover from 300 k.c. to 24 mc., modulated or unmodulated. Provision for 400-cycle audio output. Transformerless; designed to operate from 117v. A.C. mains. Circuit and construction.
—**Radio News (U.S.A.), July, 1948, p. 64.**

A test oscillator for quartz crystals. Circuit and construction of effective test oscillator of uncomplicated design. Uses one type 9001 valve, a 0-500 microammeter, and a few other components.—**Electronic Engineering (Eng.), October, 1948, p. 333.**

Peak-to-peak voltmeter. Details and circuit of electronic voltmeter based on familiar amplifier-rectifier principle, but designed to give high input impedance and zero-impedance output. Instrument has range from 0.001 volt to 1,000 volts, peak-to-peak, or 0.00035 to 355 volts R.M.S. value of sine-wave.
—**Electronics (U.S.A.), October, 1948, p. 101.**

Making standing wave ratio measurements with twin-lamp. Operating hints.—**QST (U.S.A.), October, 1948, p. 50.**

The "Coax Twin Lamp." Construction of a twin-lamp S.W.R. indicator for solid line.—**QST (U.S.A.), November, 1948, p. 25.**

PROPAGATION:

Propagation of radio waves. Details of experiments using pulse technique in oblique-incidence on the ionosphere.
—**Wireless Engineer (Eng.), October, 1948, p. 322.**

RECEPTION AND RECEIVERS:

A low-frequency converter. Circuit and construction of a converter for use with communications type of receiver to provide coverage between 100-500 kc. when receiver does not normally extend to that range. Converter oscillator with an I.F. of 1500 kc. covers from 1600-2000 kc. Bandpass mixer circuit is satisfactory for reception on this band and provides attenua-

tion of image frequencies in 3100-3500 kc. scale. Drain of single 6SA7 valve is small and converter may be connected to power supply of receiver.
—Radio News (U.S.A.), July, 1948, p. 49.

Single sideband crystal filters. Description of three crystal filters designed for a radio receiver to give twin-channel single-sideband reception. X-cut crystals in multiple section filters used to separate carrier from sidebands on an A-M wave at an I.F. of 100 kc., and to isolate the sidebands.
—Electronics (U.S.A.), October, 1948, p. 116.

A "hot" converter for 220 mc. Circuit and construction. Uses 6J6 neutralized p.p. R.F. stage, 9002 oscillator, 6J6 mixer, and 6BA6 I.F. stage.—QST (U.S.A.), October, 1948, p. 32.

TELEVISION:

Modern TV receivers. Part 4. Describes sound and video I.F. systems used by representative U.S. manufacturers and explains method of separating sound from video.
—Radio News (U.S.A.), July, 1948, p. 66.

TV sync and inter-sync systems. First part of article explaining use of pulse system in receivers to provide sync. Operational data on rectangular pulses and time constants.
—Service (U.S.A.), September, 1948, p. 22.

TRANSMISSION ADN TRANSMITTERS:

Compact C.W. transmitter. Circuit and constructional details of a compact transmitter designed for operation on 80, 40, and 20-metre amateur bands. Employs bandswitching, 6V6 Pierce oscillator, 807 buffer-double and 813 final amplifier. Cathode keying of oscillator stage.
—Radio News (U.S.A.), July, 1948, p. 42.

Putting the 826 to work. Circuits and construction of two transmitters for amateur use employing type 826 valve as final amplifier on bands up to and including 28 mc.
—Radio News (U.S.A.), July, 1948, p. 61.

Frequency-shift keying. Explanation of method of keying transmitters by frequency shift and comparison with other keying methods.—Wireless World (Eng.), November, 1948, p. 400.

Simple crystal control on 144 mc. 10 watts output from 6J6 oscillator-doubler (or tripler) and 832 amplifier. Oscillator circuit uses 8 mc. crystal with controlled regeneration, operating on third harmonic of crystal.
—QST (U.S.A.), October, 1948, p. 22.

A VFO/crystal exciter. Compact exciter combining stable VFO and crystal oscillator with five selectable frequencies. VFO uses 6SK7 oscillator and two 6F6 buffers. Crystal oscillator uses 6L6 with 807 output.
—QST (U.S.A.), November, 1948, p. 36.

So it's hard to get on VHF! Description and constructional details of two-valve transmitter-exciter using 6J6 valve in crystal-harmonic oscillator and doubler, with type 832 valve as amplifier or tripler. For 50 or 144 mc. output, 8-9 mc. crystal is used. (See Simple Crystal Control on 144 mc. above).
—QST (U.S.A.), November, 1948, p. 44.

Push-push portable transmitter. Circuit and construction of a 15-watt, 10-meter radiotelephone transmitter using miniature valves.—Radio News (U.S.A.), August, 1948, p. 40.

Transmitter stability (see Radio and Electronics Abstracts, November, 1948, p. 34). Application of points, previously discussed, to design of shielded, stabilized transmitter for L.F. (amateur) bands, using p.p. 807 type of valves in final stage.
—Q.S.T. (U.S.A.), August, 1948, p. 11.

High power on 220 mc. amateur-band transmitter with 832A driver and p.p. 4-65-A stages.
—Q.S.T. (U.S.A.), August, 1948, p. 82.

VALVES:

Base-pin connections for new U.S. valves: types 35C5: 50C5: 6BH6: 12AW6: and 6BJ5 miniatures. Reference to circuit improvements as a result of new pin connections.
—Service (U.S.A.), August, 1948, p. 12.

Infra-red image converter tube. Principle of operation. Historical developments referred to. Early British, Continental, and U.S. tubes described. First part of article.
—Electronic Engineering (Eng.), September, 1948, p. 278.

Power diodes; Part 2. The rating of high-vacuum oxide-coated rectifiers. Reference to improved system for rating which, when output current and voltage known, makes it possible to calculate required input and to determine values of associated components.
—Electronic Engineering (Eng.), September, 1948, p. 285.

Power diodes, Part 2. Details of manufacture of high-vacuum oxide-coated rectifiers. Familiarity with usual valve manufacturing processes assumed.
—Electronic Engineering (Eng.), August, 1948, p. 254.

MISCELLANEOUS:

Electronics Park. Description of the new combined H.O., engineering facilities, and de luxe manufacturing plant of the General Electric Company (U.S.) at Syracuse. Description of (1) the park and its people; (2) the engineering organization; and (3) production technique—
—Electronics (U.S.A.), October, 1948, p. 77.

Saturable reactors and magnetic amplifiers. Saturable reactors (transducers) and their use with magnetic amplifiers discussed. Consideration of core material and mode of assembly; characteristics desirable in rectifiers used with such systems; and application of magnetic amplifiers.
—Electronics (U.S.A.), October, 1948, p. 104.

A Panoramic Adaptor Unit for Amateur Transmitters and Others

Part 3

Making the Oscillator Coil

The oscillator coil, which has to have a centre frequency when not being swept of 365 kc/sec., is made from an ordinary I.F. can, and a bobbin designed for a 175 kc/sec. I.F. transformer. Only one winding from the bobbin is used, so that the first step is to saw through the former as close as possible to the unwanted winding, leaving enough former on which to wind the tickler. This consists of 100 to 125 turns of 30-gauge enamelled wire, jumble-wound as close as possible to the remaining winding. It has to be put on first, as in order to adjust the tuned winding to the right inductance, the arrangement has to be set up in a temporary oscillator circuit. The latter should use the triode section of the 6K8, so as to reproduce working conditions as closely as possible. In order to adjust the winding, all that is necessary is a broadcast receiver. The oscillator is set going, and turns are taken off until the oscillator hits 565 kc/sec. This can be identified by tuning the receiver to 2YA, on 570 kc/sec., and listening for the audio beat note produced by the oscillator when its frequency approaches the frequency of the station. To check that this is the fundamental, and not a harmonic of a lower oscillator frequency, the set should be tuned to 1130 kc/sec., where the second harmonic should be received. Incidently, the idea of adjusting the oscillator coil to 565 kc/sec. is simply that when it is loaded with capacity to bring it down to 365 kc/sec., the L/C ratio will be correct. It should have been mentioned that in carrying out this frequency test, the reactance tube should be placed in its socket, and be passing plate current. There should not be any saw-tooth voltage fed to its grid, however. Also, there should be no capacity across the oscillator tuned circuit except the stray wiring capacities, while it is being adjusted to 565 kc/sec. When the correct number of turns have been taken off, the final step is to connect across the tuned winding 75 $\mu\mu$f. of fixed mica condensers (a 50 and 25 $\mu\mu$f. in parallel) and a 3-30 $\mu\mu$f. Philips trimmer. It should now be possible to hit 365 kc/sec. by tuning the oscillator with the latter. The easiest way of finding the correct frequency is to feed a signal into the adaptor at 465 kc/sec., having first aligned the I.F. stage to 100 kc/sec., and then tune in the signal with the oscillator trimmer condenser. It is certain that the oscillator is on the correct frequency when the signal is tuned in this way, because the other frequency that could give the 100 kc/sec. beat is 565 kc/sec., and we know that the oscillator is lower in frequency than this, on account of the way in which the coil was adjusted.

Setting up the Adaptor

When the constructional work has been completed, the setting-up procedure must be followed as described here. First of all, it is necessary to see that the cathode ray tube is working properly. This can be checked in a few moments. First, the brilliance control is set so that there is zero grid bias—i.e., at maximum brilliance. The focus control is then set at about the centre of its travel, and the saw-tooth input voltage to the amplifier is turned well up. Then, the diagonal shift control is moved until some sort of trace is seen on the screen. When this is found, however blurred it may be, the brilliance and focus controls are adjusted until the trace is sharp, and the shift control, until it travels across the screen and in doing so passes as near to the centre of the tube as possible. The focus of the trace will to some extent be affected by the shift control, since, if it is a long way out, it is not possible to obtain a very good spot, but the effect is non-existent once the undeflected spot is nearly centred, or when the trace passes near the centre. When this has been done, the alignment of the signal-frequency circuits can be undertaken.

The first job here is to align the 100 kc/sec. amplifier stage. This really requires a signal generator, but can be done without one by making use of the fact that we have built in to the adaptor the means for aligning the 100 kc/sec. circuits visually. To do this, it is only necessary to sweep the oscillator frequency, and to apply to the input grid of the 6K8 a signal which will beat with the F.M. oscillator to produce a signal out of the 6K8 at frequencies round about 100 kc/sec. In this arrangement, the exact I.F. for the 100 kc/sec. channel does not matter very much, as long as the circuits can all peak to the chosen frequency. However, it is best to align the circuits to exactly 100 kc/sec. if possible, so that trouble will not be found in setting the F.M. oscillator.

The 100 kc/sec. amplifier stage is lined up in the usual manner, and with no modulation applied to the oscillator, the height of the trace on the screen can be used as an output indicator. After the stage has been peaked up, the sweep control on the oscillator is kept at zero, and a *modulated* signal at 465 kc/sec. is fed into the 6K8 grid. The oscillator trimmer condenser is then adjusted until maximum output is given by the detector, as judged by the height of the vertical deflection. This means that the fixed oscillator frequency has been adjusted to 365 kc/sec. Now, if the sweep control is advanced, and the X amplitude control, R_{24}, is turned up so that a horizontal trace appears, there will be a picture on the screen of the selectivity curve of the 100 kc/sec. I.F. stage. Now, when the 465 kc/sec. input is altered slightly in frequency, the peak will be seen to shift to one side or the other, depending on the side to which the detuning takes place. When the alignment has been carried out in the manner described, the 465 kc/sec. signal should appear somewhere near the centre of the trace. In order to measure the amount of frequency sweep obtained, R_{22} should be set at approximately half-scale, and the frequency of the signal generator shifted until the peak is right at the end of the trace. Since the signal generator is fed at the moment into the grid of the mixer, and *not* through the input transformer, the amplitude of the signal peak should not change very much as the generator is altered in frequency. When the peak is exactly at the end of the trace, the frequency is read from the signal generator's calibration, and the value is noted. Then the generator is tuned back through 465 kc/sec. and on to the other side, until the peak is at the other end of the trace. The frequency is measured again, and noted. If the sweep control R_{22} has not been advanced too far, the ends of the trace will be found to be almost the same number of kilocycles from the centre-frequency, but of course in opposite directions. If the difference is large, try reducing the amount of frequency sweep and measuring again. It should be possible to get a sweep of 25 to 30 kc/sec. on either side of 465 kc/sec. with fairly good linearity. In any case, slight loss of linearity does not matter very much, as in the finish the sweep control will be set and the frequency calibration of the

trace done by hand, and a scale pasted to the face of the C.R.T. The manipulation of the controls will give a much better idea than any description just how the adaptor works.

The next step is to tune the circuits of the 465 kc/sec. input transformer to resonance. This is done by feeding the signal generator, tuned to exactly 465 kc/sec., into the input terminal of the adaptor. The signal peak will show on the screen, and the transformer can be tuned up by using the height of the peak as a resonance indicator. When both windings have been tuned, it is instructive to shift the frequency of the signal generator again and note the effect. This time, as the peak moves off to one side or the other, the amplitude of the peak will not remain constant. It will be a maximum when the signal is on 465 kc/sec., and will fall off on either side, because of the selectivity of the 465 kc/sec. transformer. In fact, if a tracing is made of the tip of the peak on the face of the tube, as the frequency is varied, the result is the response curve of the 465 kc/sec. transformer. It is interesting to see how very much wider this is than that of the 100 kc/sec. amplifier, which is visible the whole time, and one can get some idea of just how much more selective the 100 stage is than the 465 stage could ever be, even allowing for the fact that here we have only one 465 kc/sec. transformer.

Now, only two things remain to be done. First, the input transformer, which has just been aligned, has to have its windings detuned, one on either side of resonance, so as to widen out the input response of the adaptor. One can see, with T_1 tuned to resonance, how the available sweep of the adaptor would be fairly useless unless the selectivity ahead of it is removed.

The other thing to be done is to set the centre frequency of the F.M. oscillator so that a 465 kc/sec. signal into the adaptor is received exactly at the centre of the trace.

The easiest way to detune the windings of the input transformer in the proper way is to proceed as follows. A small fixed condenser is attached in parallel with one of the windings, *after* they have both been peaked to resonate at 465 kc/sec. This winding is thereby detuned to a frequency lower than 465 kc/sec. The tuning is restored by screwing out the trimmer of the winding to which the fixed condenser has been attached. Now we have the situation that the transformer is still tuned to resonance at 465 kc/sec., but with a small fixed capacity across one winding. Now, the fixed capacity is removed, *and connected permanently across the other winding.* The winding to which the condenser is *now* wired must have been tuned to a lower frequency than 465 kc/sec., while the one to which it was temporarily attached must now be tuned to a higher frequency, because its trimmer was screwed out to restore resonance. What we have done is simply to find a method of adding a capacity to one winding, and subtracting an exactly equal capacity from the other. Admittedly, this does not detune the windings by exactly the same amount, since the frequency of a tuned circuit is not a linear function of the capacity in the circuit, but for the small fractional detuning that is necessary, the results are quite near enough. All that matters is that the response of the input circuit should be wide enough for a signal at the extreme end of the frequency sweep to have a reasonable amplitude, after conversion to the 100 kc/sec. I.F.

The exact amount of capacity that is needed in the above process cannot be specified, and is a matter for individual experiment with the adaptor in conjunction with the receiver with which it is to operate. A recommended value for trial, however, is 25 $\mu\mu$f. After the above detuning procedure has been carried out, it is time to attach the adaptor to the receiver, but *not before.* Until alignment of the adaptor has reached this stage, however great the temptation to "hitch it on" this should be avoided, as the results will be quite disappointing unless the adaptor is very near its final state of alignment. In attaching it to the receiver, the first thing to do is to connect a small condenser of, say, 10 $\mu\mu$f. directly to the plate of the receiver's mixer valve. Next, the adaptor is placed in what will be its final position on the operating desk, and the shortest length of wire is measured which enables the connector at the front of the adaptor to be wired to the mixer plate of the receiver. A good place for the adaptor is on top of the receiver, as it then becomes an integral part of the latter, and it is no trouble to observe the 'scope pattern at the same time as the receiver is being tuned. Also, a short piece of shielded wire can be brought through the top of the receiver cabinet. It is important that the shielded wire should be as short as possible, since its capacity to earth forms a capacity voltage divider with the 10 $\mu\mu$f. condenser used at the mixer plate. Thus, the smaller the capacity of the shielded wire, the smaller will be the loss of signal in this voltage divider. The 100k. resistor in series with the input terminal is wired *inside the adaptor,* and has the purpose of isolating to some extent the capacity of the input cable from the first tuned circuit of the input transformer. If this resistor were omitted, the signal presented to the adaptor would be somewhat larger, but the capacity of the cable would then be directly connected across the first tuned circuit, and would upset the tuning adjustment that has been so carefully carried out. However, the gain of the adaptor is sufficient, even with the 100k. resistor in circuit.

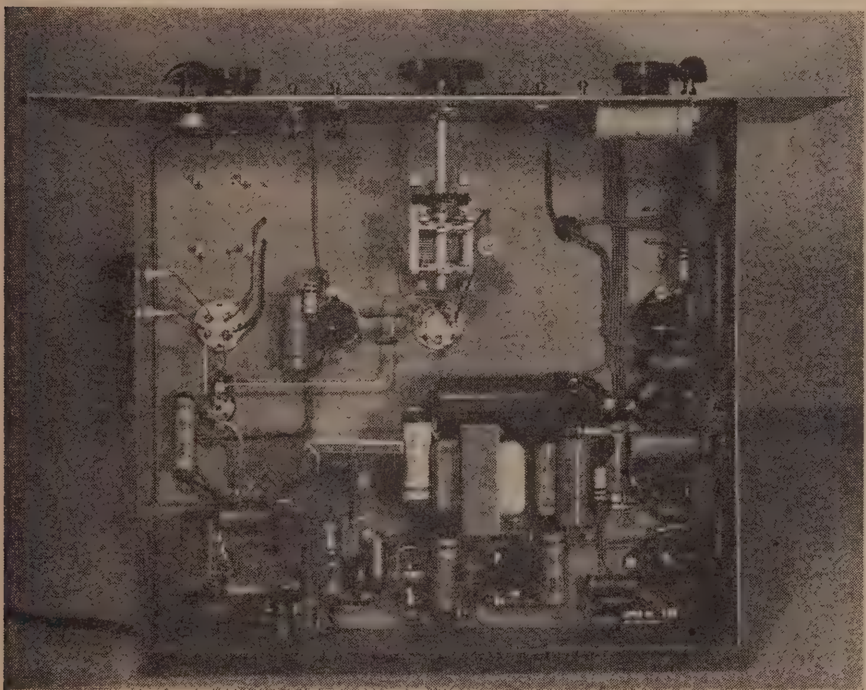
When the adaptor has been connected in the above way, the final adjustment can be made. The attachment of even the small coupling condenser specified will have thrown off the tuning of the mixer plate winding, if only slightly. The first step is therefore to readjust the tuning of this winding, and to check the alignment of the I.F. amplifier of the receiver. This is done with an output indicator on the receiver itself, and during the process the adaptor should be connected, but not working. The I.F. channel of the receiver is then aligned in exactly the normal way. After this, the adaptor is turned on. A signal is fed into the receiver aerial terminal at any convenient frequency, and is tuned in by ear or by the magic eye or S-meter in the usual way, still taking no notice of what may happen in the adaptor, or on its screen. Next, the gain of the adaptor is adjusted so that a reasonable deflection is obtained, showing the signal that is tuned in on the set proper. High adaptor gain should not be used at this stage, as it will show up a multitude of other signals, in all probability, that will only confuse the issue. The sweep control R_{22} is then set fairly wide open so that the trace will represent plus and minus 50 kc/sec. or more. This is really too wide a sweep for most practical purposes, but is useful for the final adjustment. Now, the receiver tuning is left set, and the signal generator tuning is varied on either side of the spot to which the receiver is tuned. The signal on the screen of the adaptor will move from side to side on the tube, and the job is now to observe the way in which it varies in amplitude as its frequency is changed. If there is a very pronounced peak in the response at the centre of the trace, then it simply means that the adaptor's input transformer has not been sufficiently staggered, and therefore that the dip in response due to the detuning is not great enough. If this is the case, all that has to be done is to carry out the tuning process for T_1 again, this time with more added capacity than was used

(Continued on page 48.)

JUNIOR COMMUNICATIONS RECEIVER

(Continued from page 15.)

output for the second I.F. amplifier. This frequency is inside the range of operation of the oscillator of an ordinary broadcast set, so that a special oscillator coil is not needed. The coil used in the prototype was one recommended for use with a 420 mmfd. gang condenser in a broadcast receiver, and for a 6A8. The circuit diagram shows a resistor, R_{13}, in series with the oscillator plate of the ECH35. In the original, this was not needed, but it has been drawn on the circuit for the sake of completeness. It can be be used, if desired, to limit the strength of oscillation in the ECH35, thereby reducing the radiation of harmonics from this oscillator, should this be found necessary. These harmonics, if encountered, will not show up as whistles, unless they happen to come exactly on the frequency of a signal which is coming in through the aerial. They behave just as do outside signals, so far as the front end of the set is concerned, and can be tuned in in exactly the same way. If they occur, they can usually be recognized by their steadiness and by the fact that their strength depends hardly at all on the aerial, whether this is connected or not. However, although we expected to find some of them, since they are a well-known feature of double superhets., none was apparent, and R_{13} was found not to be necessary. If one is to be tried, a value of 1000 ohms should have quite a noticeable effect in reducing the oscillator strength, as shown by the reduction in grid current. Since the circuit was made into a printing block, it has been noticed that a condenser has been left out of the ECH35 part of it. R_{14}, joining the primary of T_3 to H.T., should be bypassed by a 6.05 mfd. condenser at the transformer end. This would not be a serious omission in practice, but it is well to set it right at the outset. The 6H6, V_5, acts as a second detector, A.V.C. rectifier, and noise limiter. It is enabled to fulfil all three functions because of the fact that there is no voltage delay at all on the A.V.C. Normally, this is not considered good practice, as it means that the A.V.C. starts to work even on the weakest signals. This is not a disadvantage at all in a set of this kind, however, as, even so, there is much more amplification in the set than can ever be used, in spite of its good signal-to-noise ratio. It has the advantage, however, of simplifying the circuit considerably, since it enables two diodes to do the work that would normally take three, which is an awkward number to cater for.



The left-hand diode of V_5 is the second detector and A.V.C. rectifier. At this point we will have to discuss the back-bias scheme, in order to explain the rather unusual-looking detector circuit. The back bias is provided by R_{26}, which is connected between the chassis and the centre-tap of the high-voltage secondary on the power transformer. By this means, the whole of the current passes through R_{26}, in such a direction as to make the right-hand end negative with respect to the chassis. The resistor thus becomes a source of negative potential, to the extent of some 25 volts. Now, to get back to the second detector circuit. The load resistance is made up of R_{19} to R_{22} inclusive, all connected in series. In most circuits, the free end of R_{22} would be earthed, and so would the cathode of the detector diode. As far as R.F. and audio voltages are concerned, this is still true, since the cathode is bypassed to earth by C_{24}, while the end of R_{22} is connected directly to the cathode, so that it is bypassed by C_{24} also. We can thus see that the detector circuit is unusual only so far as its D.C. relationships are concerned. Forgetting for the moment about the presence of R_{23}, which is merely a decoupling resistor and has no effect on the D.C. voltages in the circuit, it can be seen that the potentiometer R_{25} enables the cathode of the detector to be made negative, up to the maximum of 25 volts. As in all simple A.V.C. systems, the D.C. voltage developed by the detector is smoothed, to remove audio components, by a resistance capacity filter, R_{19} C_{22}, after which the A.V.C, line goes off to the grid circuits of the controlled valves. By this means, too, any D.C. voltage that may be placed on the A.V.C. line by the manual gain control is also supplied as a bias to the controlled valves. Thus, when the slider of R_{25} is at the right-hand end, a voltage of -25 is placed on the right-hand end of R_{22}, upon which it also appears on the A.V.C. line, biasing the valves. Now, any voltage produced by the detector diode on the control line is added automatically to the voltage from R_{25}. At first sight, one might expect that placing a negative voltage on the cathode of the detector diode would cause it to conduct all the time, thereby spoiling its

detecting action, but this is not so, since the plate of the diode also receives the negative voltage from R_{25}, as it is connected through the I.F. transformer and load resistor chain to the same place as the cathode. In other words, the negative back-bias voltage is applied equally to plate and cathode of the detector diode, the resultant effect being exactly nil. R_{24} limits the minimum bias to —3 volts, so that, even at full gain, the grids of the controlled tubes cannot become less negative than this.

No A.V.C. Switch

The reader may perhaps have noticed that there is no switch in the circuit whereby the A.V.C. can be turned off, leaving manual control only. This does not mean that the A.V.C. is working the whole of the time, whether it is wanted or not, because the effectiveness of the A.V.C. can be reduced to any extent that may be wished simply by advancing the audio gain control. Of course, on very strong local signals, the A.V.C. will still be effective, up to a point, even with the controls in their extreme positions, but this does not matter at all, as it is always wanted under these conditions, in any case.

Long Time-constant A.V.C.

A feature that is not often found, even in the most expensive commercial sets, is a switch by means of which the time-constant of the A.V.C. action can be varied. In this case, there are only two positions, the switch being S_2 on the circuit diagram. As can be seen, all this does is to connect a large condenser across the A.V.C. line, bringing the time-constant up to a matter of a second or so. This is very useful for copying C.W. with the A.V.C. in action. When at attempt is made to use A.V.C. on ordinary receivers for C.W. reception (in many of them it is not possible, because the A.V.C. is automatically switched off when the B.F.O. is brought into action), a most annoying effect comes into play. If the speed is fairly fast, the time-constant of the A.V.C. circuit is long enough for the sensitivity of the set to remain low while a word is sent, but during the gap between words, which is longer than that between letters, the sensitivity of the set is able to rise, and the noise-level comes up strongly after every word. When the long-time constant is used, however, the A.V.C. does not let go until about a second after the last dot or dash has come along, so that, before the sensitivity can rise, the next signal has come along, and keeps the gain of the set down to the figure set by the average strength of all the dots and dashes. The time constant in operation without C_{16} in use is quite short—shorter than is found in ordinary broadcast receivers. This is done on purpose, so that the set will be able to cope with some of the faster types of fading that are encountered on the shortwave bands.

Calibrated Bandspread

In this set a novel and very useful idea has been put into practice with conspicuous success. It enables accurately calibrated bandspread to be obtained on any desired bands, up to the number that can be accommodated on the main dial of the set. First of all, some description of the signal and first oscillator circuits is necessary.

It will be noticed that there are three condensers in the oscillator circuit. C_5, the band-setting condenser, is a variable of 100 mmfd. maximum capacity. C_8 is the oscillator bandspread condenser, and is the one driven by the main dial, which is the type made for calibration by the user, several blank scales being provided, in addition to a 0 to 100 scale round the outside. The third condenser, C_6, is a Philips 3–30 mmfd. trimmer, and is used simply to pre-set the amount of variation obtainable when C_8 is turned from maximum to minimum. C_6 is set once and for all, after which it remains untouched. On the signal side, we have two condensers. The variable is of the same type exactly as C_5, and has a maximum capacity of 100 mmfd. In series with it is C_1, which is a fixed condenser of 200 mmfd. The purpose of this is to limit the capacity variation of C_2 so that with it a frequency variation of approximately 2:1 is obtained. This is because the same order of frequency variation is obtained in the oscillator. In fact, here the variation is very slightly greater than 2:1, so that there can be a small overlap between each two bands. The coverage of the receiver is approximately 3 to 30 mc/sec. in four bands, so that four sets of two coils each, eight coils in all, are needed for complete coverage. How, then, is the calibrated bandspread arrived at? There is nothing in the scheme outlined which has not been done before, as far as the circuit is concerned, since it is only the simplest of parallel bandspread arrangements, and works only on the oscillator tuning. There is no need at all for the first detector tuning to be spread, as it is the oscillator which governs the frequency to which the set is tuned, the first detector tuning being used simply to peak the signal up for maximum response. Most sets which use the scheme outlined here do not have provision for calibrating the bandspread, but merely have two dials, one for the band-setting condenser, and the other for the bandspread condenser. When it comes to calibrating the bandspread dial, this is not so satisfactory as might at first appear, since, on the shortwave bands, tuning is very critical with the bandsetting condenser, which is the real reason for having a spreading dial at all. The trouble as far as calibrating the latter is concerned is that it is not possible to set the band-setting dial accurately enough for a calibration to be made for the bandspread dial that means anything at all. Here, the difficulty has been overcome in the following way.

The band-setting condenser has not been provided with a dial at all. This might seem to have made the situation worse instead of better, but here is the catch. The band-setting condenser, whose tuning knob is the small pointer-type knob directly underneath the main dial, is driven by the stepping mechanism of a wavechange or other multi-position wafer switch. The correct one to buy is a swich that has a number of positions —not fewer than six—and a short quarter-inch shaft. Do not get one whose shaft, on the wafer side of the supporting plate, is a flat strip. The right kind is the one in which the wafers are held in position by means of two flats ground on the shaft, which, in the round portions, is still one-quarter of an inch in diameter. Only a short piece of shaft is needed inside the chassis, so that one of the currently available 10 or 11-position single-wafer switches will do admirably.

The idea is this: The band-setting condenser cannot be turned continuously, but only in steps, as determined by the action of the switch mechanism. Thus, in order to tune over the whole range covered by one oscillator coil, we turn the band-setting condenser fully anti-clockwise, and then tune with the bandspread dial, which is the main dial. Having come to the end of this, the band-set condenser is clicked round to the second position, and the bandspread condenser is tuned back to the other end of its travel. The band-set "switch" is clicked over to the next position, the bandspread condenser is tuned round again, and so on until the last position of the band-set condenser has been explored

(Continued on page 48.)

A Practical Beginners' Course

PART 29

At this point in our course, it is perhaps time to leave receiving sets to themselves for a while and to turn to the subject of A.C. valves and their operation. Sooner or later, everyone who has a yearning to carry on with the study of radio wants to do away with batteries and use valves which can be operated from the A.C. mains. In order to do this, we need to use some means of turning the alternating current from the mains into direct current that can be placed on the plates, screens, etc., of the valves. Unfortunately, it is not possible to use battery valves in this way—at least, without a certain amount of trouble—because it is quite difficult to smooth out A.C. ripple from a low-voltage D.C. supply that has been made from A.C. in this way. Smoothing the high-voltage supply is quite easy, so that if one wants to eliminate the B battery, and still use battery valves, this can be done by retaining the A battery for lighting the filaments.

As we have pointed out before, the only fundamental difference between battery valves and A.C. valves is that the latter almost always have a heater and cathode instead of a filament. This enables the heater to be run from A.C. without any attempt at smoothing, since there is no electrical connection between the two elements, and the large size of the cathode and the great amount of heat it stores ensure that the stream of electrons from the cathode does not vary at the A.C. frequency and so cause the valves to amplify this as hum. For this reason, all the circuits we have used for battery valves have their counterparts using A.C. valves.

The name "A.C. valve" is a very bad one really, as one would expect it to mean "valves which can be operated by alternating current." This is clearly not the case, since, just as with battery valves, they need D.C. for the plate and screen-grid supply. This has to be made from the A.C. mains by a valve specially designed for the purpose, and called a RECTIFIER. This is a diode, just like the diode that can be used as a detector, except that it is much larger, because it has to pass a great deal of current instead of only a few micro-amperes, as does a detector. It usually has a heavy filament, since in most cases there is no point in giving it a heater and cathode like the receiving valves. Some rectifiers do have a heater and cathode, but for a quite different purpose. Most of the rectifiers used in radio sets and to supply the direct current for small valves really consist of two diodes in the same glass envelope, and with only one filament between them. The reason for this will be apparent when we come to discuss different rectifier circuits. The most commonly used one, called the "full-wave" rectifier circuit, calls for two diodes, and, if we like, two separate valves can be used, but since in this case the filaments would be in parallel, it makes the power supply part of a set much cheaper if the two diodes are made in the same envelope. Thus, the majority of rectifier valves intended for use in the power supply parts of sets contain three electrodes, a filament, and two plates which are connected as will be seen later. Other rectifiers are indirectly heated. That is to say, they have a heater and cathode instead of a filament, just like other A.C. valves.

We will now go on to say something more about alternating currents, and what they are, and this time the reader will be introduced to the idea of representing things by means of graphs. This is a very worth-while subject, as a great many of the things we need to know in radio are most easily shown graphically.

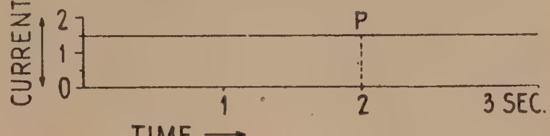


FIG. 37

This figure gives a graphical representation of a direct current and its behaviour with respect to time.

What is A.C.?

Before going on to describe a power supply worked from the mains, it is very important to give some idea of what alternating current is, since without some ideas on this subject the builder is liable to encounter a good many snags. It is well known, of course, that a battery produces direct current, or D.C. for short. This simply means that, in any circuit powered by a battery, the current can flow in only one direction—from the positive terminal of the battery through the external circuit to the negative terminal.

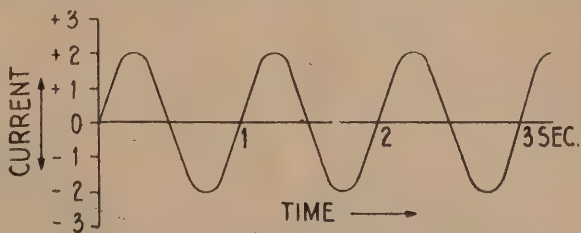


FIG. 38

Here is illustrated the behaviour of an alternating current with respect to time. Note that the value of current is changing constantly, and flows first in one direction and then in the other along the wire carrying it.

Alternating current is so called because it flows, not in one direction along a wire, but alternately backwards and forwards. Thus, a source of alternating current, such as the two terminals of an electric lamp socket, cannot be said to have one positive and one negative terminal, because each becomes positive or negative at the rate at which the reversals of current occur. The easiest way to describe this behaviour on the part of an alternating current source, such as an alternator (A.C. generator), is by means of a graph. No doubt many readers of this article have had little to do with these useful devices, but a start must be made some time, and when the idea of a graph has been grasped, its extreme usefulness will be readily seen.

Figs. 37 and 38 are graphs showing respectively the behaviour of direct and alternating currents with regard to time. The introduction of the time factor into our thinking about electric currents is the only

new idea presented, but is made quite clear by the figures. The horizontal and vertical lines are called the **axes** of the graph in each case, and their intersection is called the **origin.** Along the vertical axis we represent current, and time is measured along the horizontal axis, the value at the origin in each case being zero. Between the axes we have a line representing in these cases how **current** changes as time goes on. The only thing which may cause difficulty to some is seeing how any particular time can be given for a value of 0 (nought). However, this is quite easy, for the time 0 (at the origin) simply represents the time at which we start measuring, and can be any particular moment we choose. The time axis is marked off in seconds. Thus, the time at the origin could be 12 noon, or midnight, or breakfast time, or any time at all, but this is quite unimportant, because all that we are interested in is what happens 1, 2, 3, etc., seconds after any time we like to think of.

First, let us consider Fig. 37, which represents the behaviour of a direct current with respect to time. It will be noticed that the vertical axis has been marked off in amperes, the unit of current, just as the time axis has been marked off in seconds. The graph therefore represents a current of 1.5 amperes D.C. If we take, say, two seconds after the start of the measurement of current and erect a line perpendicular to the time axis, this cuts the graph at P. If now we proceed horizontally from P to the current axis, this will give us the value of current at the time of 2 seconds. In this case it is 1.5 amperes. If we do the same thing at, say, 3 seconds, we find the current is still 1.5 amps. Thus, the graph tells us that at all times the value of current is the same—namely, 1.5 amps. This is a graphical demonstration of what is meant by a direct current. A direct current of 1 amp. would be represented on the graph by a line parallel to the time axis, cutting the current axis at the 1-amp. mark.

Now, considering Fig. 38, one important difference

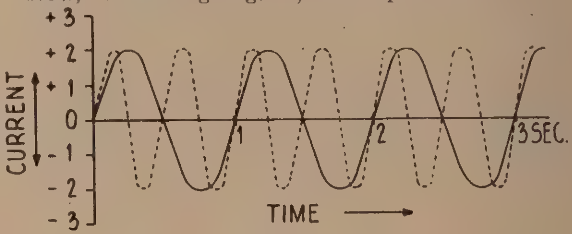


FIG. 39

Here we have two alternating currents, identical in all respects, except for frequency. The dotted one has twice the frequency of the solid one, since two complete cycles of the first take place during one cycle of the latter.

can be seen. The current axis has been extended on both sides of the time axis, and we have introduced the term plus and minus to represent the top and bottom halves of the current axis. This procedure allows us to introduce on the graph the idea that current can flow in a wire in either of two directions. Suppose we have a wire laid parallel to the lines of this page. We could call a current flowing from left to right **positive,** and a current flowing from right to left would then have to be called **negative.**

The first thing which will be noticed about the graph of Fig. 38 is that part of the time the current is shown as above the time axis, and therefore as flowing from left to right in our imaginary wire, while the rest of the time it is flowing from right to left and is therefore shown below the time axis.

It can be seen, too, that at certain times the current is zero and that at all times the value of the current is changing. In Fig. 38, for instance, we have drawn a graph which represents a current that reaches a maximum value of 2 amperes in one direction, decreases, passes through zero, and builds up to a maximum value of 2 amperes in the opposite direction. This is an exact description of just how an alternating current behaves.

Fig. 38 also explains the meaning of the term **frequency**, often found in dealing with alternating currents. At the starting time, marked zero, the current also is zero. A half-second afterwards the current passes through zero again, while one whole second after the start the current passes through zero a third time. Thus, between zero time and 1 second, the current has passed through its positive maximum, zero, and its negative maximum, and has reached zero again. If now we trace what happens between one and two seconds after the start, we find that the whole process is repeated, and so on for as long as we like to continue the graph. The part between 0 and 1 second is called one **cycle.** Therefore, the part between 1 and 2 seconds is also one cycle. We can say, therefore, that the alternations take place at a rate of one cycle a second, or that the **frequency** of the current is one cycle a second. Fig. 39 shows two alternating currents drawn on the same graph. Each reaches the same maximum value of 2 amps. in each direction, but one goes through two complete cycles every second. Its frequency is therefore two cycles a second.

This rather long description should have given a clear enough idea of the nature of an alternating current for us to proceed to the question of how we can produce from it a direct current, suitable for supplying to the plates of valves, as a substitute for batteries.

Rectification

The device used for changing A.C. into D.C. is known as a rectifier, and may be—in fact, usually is—a valve. The type used for this purpose is the simplest of all valves, the diode. It is well known that a diode will pass current only in one direction. For instance, once the filament is heated, if we connect a battery between plate and filament, we find that if the positive terminal of the battery is connected to the plate, a current will flow through the valve just as if it were a piece of wire. However, if the negative terminal of the battery is connected to the plate, no current flows at all. Thus, the valve can be regarded as a gadget which can be wired into a circuit and will allow current to flow in one direction only.

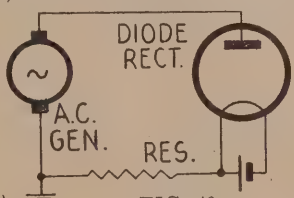


FIG. 40

Circuit showing how a diode valve is used to rectify an alternating current supplied by a generator. It does this by conducting current in one direction only, as illustrated in Fig. 41.

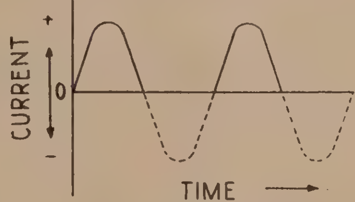


FIG. 41

Fig. 40 shows a simple circuit consisting of an

(Continued on page 48.)

TRADE WINDS

N.Z. RADIO MANUFACTURERS' FEDERATION ANNUAL CONFERENCE

Seventeen delegates representing practically the whole of the New Zealand radio manufacturing industry engaged in one and a half days' discussion on 17th and 18th November, 1948, at the third annual conference of the New Zealand Radio Manufacturers' Federation in Rotorua, which has been acclaimed the most successful gathering of radio manufacturers since the inauguration of the organization. Topics affecting all aspects of radio receiver production were exhaustively discussed.

Federation Adopts Title R.M.A.

Coming into line with radio manufacturers' organizations in other parts of the world, the conference adopted the title R.M.A. for all future publicity and trade reference purposes. Main speaker to the proposal, Mr. George Wooller (Auckland), pointed out that the adoption of the internationally known title would bring the Federation into line with the British, American, French, and other radio manufacturers' organizations, but would not necessarily entail the alteration of the formal name of the Federation. A further proposal adopted was the preparation of a universal R.M.A. sticker for use by member firms.

Sales Tax Remmission Urged

Deep concern at the continued incidence of the 20 per cent. sales tax on receivers was expressed by members.

"Radios in the homes of the people have become essential modern amenities of equal importance with normal household furniture, which is substantially tax-free," said the President (Mr. Wm. J. Blackwell). "It should be noted that when the Labour Department assesses the rental value of a furnished house, radio sets are included as furnishings—yet another point in support of our claim for early remission."

It was pointed out by Mr. Ralph Slade that the New Zealand tax was twice that imposed in Australia.

Conference resolved to request the Minister of Customs to remit the tax at an early date.

Guarantee Periods

Consideration was given by R.M.A. to a radio traders' request that manufacturers should investigate the possibility of the introduction of a standard period of guarantee for radio receivers. It was finally decided that members should be recommended to consider introducing a standard period of guarantee on radio receiving sets of 90 days from date of sale by the retailer.

Interesting suggestion also was the possibility of the introduction of a standard form of guarantee by all R.M.A. members. The compilation of the standard form has been left in the hands of the incoming executive, and will receive further consideration by the respective trade groups in the coming months.

Television Inquiry

"That this conference, in view of the interest displayed in Australia in television, requests that some similar interest be created in New Zealand."

The above remit as submitted by the Wellington Trade Group was adopted in amended form, and the Director of Broadcasting (Professor James Shelley) subsequently advised that the engineers of the Broadcasting Service were keeping a close watch on overseas development in television engineering. It was pointed out by the Director that the principle difficulty at present in establishing a television service in New Zealand was the extremely high cost of equipment and of the production of high-class programmes which would maintain the interest of listeners, or "viewers," to justify in their opinion the payment of a very high annual licence which would undoubtedly be necessary.

"The topography of New Zealand is such that the range of coverage which could be expected from any one station would be severely restricted, and this must inevitably add considerably to the cost of any possible television service," said Professor Shelley, in concluding his reply.

WM. J. BLACKWELL, M.Brit.I.R.E.
Re-elected unopposed as President

Deterioration in Reception Conditions

In moving a remit regarding the recent deterioration in reception conditions, Mr. Slade pointed out that numerous reports of definite deterioration in reception conditions following the changes in frequency and call-signs had been received from various sources. It was decided that contact should be made with the Director of Broadcasting in an endeavour to seek an expression of the opinions of the Broadcasting Service engineers as to whether or not reception conditions had improved since the time of the frequency changes. It was also decided to point out to the Director that there appeared to be general dissatisfaction. R.M.A. is collecting further information and evidence on the matter.

Patents Committee

"It is desired to place on lasting record the thanks and very since appreciation of each and every member of the Federation to members of the Patents Sub-committee (Messrs. Cunninghame, Collier, and Gifford) for their untiring efforts, devotion of many hours of their personal time, and admirable handling of a long-standing problem of paramount importance," stated the president in his annual report, when commenting upon the submissions made to the Patents Commission on the question of patents and royalties. The sub-committee, in conjunction with legal counsel (Mr. W. J. Sim, K.C., and associates), had drawn up a 21-page case and had also presented some 64 pages of supporting evidence.

Publicity Campaign

Delegates discussed all aspects of the R.M.A. "Radio in Every Room" campaign. It was stated that the co-operation of many retailers had been forthcoming, but that there seemed to be a lack of appreciation of the vast potentialities of the campaign on the part of some other retailers. It was generally felt, however, that the trade as a whole was commencing to appreciate the efforts of the manufacturers and would give increasing support to the far-sighted plan for more than one radio in every home.

Election of Officers

High tributes were paid to the President (Mr. Wm. J. Blackwell) for his outstanding leadership of R.M.A. over the past year. Speakers included Messrs. Collier, Cunninghame, Slade, Shiel, and Spencer. Mr. Blackwell was unanimously re-elected unopposed as President for the ensuing year.

In expressing to the meeting his sincere thanks for the honour bestowed upon him, Mr. Blackwell felt that, with the support of all members, R.M.A. would be largely instrumental in overcoming all problems which might face the industry in the coming year.

Mr. P. C. Collier, of Wellington, was unanimously declared elected Vice-president.

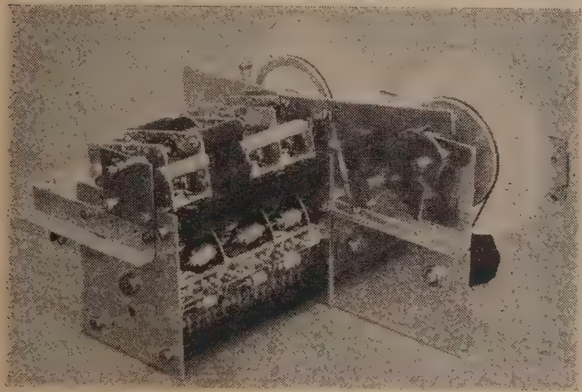
Thanks were passed to Mr. Shiel for his assistance and activities as Vice-president throughout the past year.

THE EDITOR'S OPINION

THE "DENCO" ALL-WAVE COIL TURRET

We have recently had an opportunity of examining in detail, both electrically and mechanically, a sample of the British "Denco" coil-turret, Type CT4, which is being handled in this country by Messrs. Rhodes Radio and Electrical Supplies, Auckland.

We had been awaiting the arrival of these units with considerable interest, having seen them advertised, not only in our own pages, but in British magazines as well. On paper, the CT4 seemed to be an excellent thing of its kind, and, moreover, one which would be of considerable interest to all those who have been wanting to build themselves a communications receiver. In doing this, the outstanding difficulty is the design and construction of a suitable coil unit, especially where band-switching is to be made use of. The remaining circuits of even a



Back view of the C.T.4

complex receiver are well within the scope of the experienced amateur designer, but when it comes to the coil unit, he is up against a problem which, even if he is technically able to solve, on paper, requires considerably more in the way of instrumental resources than he is usually able to provide. Briefly, if a well-designed and constructed coil assembly is available, then at least 90 per cent of the labour and difficulty in constructing a communications receiver without considerable laboratory resources, is done away with. Hence the undoubted interest shown by a great number of enthusiasts in the CT4. Of course, should such a unit be unsatisfactory from any point of view, either electrical or mechanical, then no trouble is saved at all, and it is with much pleasure that we are able to report most favourably on the performance and construction of the "Denco" CT4.

Specification

For those who may not have seen previous descriptions of this unit, a résumé of the main features will be of interest.

Frequency Coverage:

The overall coverage of the unit is 175 kc/sec. to 36 mc/sec. This is achieved in six bands which themselves cover:—

(*a*) 175 to 525 kc/sec.
(*b*) 515 to 1,545 kc/sec.
(*c*) 1.65 to 5.0 mc/sec.
(*d*) 4.8 to 9.6 mc/sec.
(*e*) 9.4 to 18.8 mc/sec.
(*f*) 18 to 36 mc/sec.

There are no doubt some who will deplore the fact that two bands are used in providing broadcast and low-frequency coverage, but even if one's interest is almost in frequencies above 3 mc/sec., it is often of great assistance to have a receiver which covers not only the broadcast band but low frequencies as well. Not that one may ever use the set to listen to low-frequency stations, but those who do any amount of experimenting with receivers, or with coils for them, will realize at once the usefulness of a receiver which covers the usual I.F. frequencies.

There is a small gap in the coverage between bands (*b*) and (*c*). This is only 105 kc/sec., and lies in a particularly unimportant part of the spectrum. It is, of course, essential to the proper working of the completed receiver, since a superheterodyne can never tune through its own I.F. In this case, the I.F. is 1,600 kc/sec., and it is an indication of the excellent electrical design, that complete stability has been achieved at frequencies as close to the intermediate frequency as this.

Band-spread:

A novel and ingenious method of band-spread is used. The three-gang condenser is mounted with its "stators" and frame not fixed, but in such a way that they can be moved over a small arc by means of a cam and lever. The latter is spring-loaded, so that it bears constantly on the cam, which is rotated by means of the band-spread dial. The latter is geared with a string-drive mechanism to the band-spread knob, and the cam is so shaped that an essentially linear frequency variation is obtained. On the band-spread dial are directly calibrated, on separate scales, the 3.5, 7, 14, 21, and 28 mc/sec. amateur bands, and for logging purposes on other frequencies there is a scale round the outside of the dial arbitrarily marked in divisions from 0 to 340.

This combination of electrical and mechanical band-spread turns out to be an excellent one in all respects. If the mechanical execution of a scheme like this were not all it should be, the result would be horrid to contemplate, but in the units we have seen, there is a complete absence of back-lash, the calibration holds remarkably well, and the whole arrangement is above reproach.

Trimming and Padding:

All coils (which are wound on polystyrene formers and sealed in place with polystyrene dope) are provided with iron-dust slugs, so that their inductances may be adjusted for optimum tracking and padding, while all trimming condensers use the now well-known Philips trimmers, which with their low losses and high electrical and mechanical stability are instrumental in keeping the alignment of the turret intact over long periods of time. This was amply demonstrated by the fact that the unit tested by us, which had been aligned in England prior to the journey out, required only minor adjustments on all bands to restore the alignment to the "on the nose" condition. In fact, without the aid of instruments, it would have been impossible to tell that the unit was the slightest bit out of alignment at all. Of most interest to the user is the fact that even should the unit need alignment, this is a very simple process indeed. With the I.F. of 1,600 kc/sec., the adjustments of the oscillator coils would have to be almost impossibly awry for such difficulties to occur as alignment to the image frequency, by mistake.

In the literature provided, claims are made that the sensitivity of the unit is constant within 6 db. of any band. Now this is extremely good performance, for even the best of receivers, and tests showed that the claim was fully substantiated.

Adaptability:

The turret is not supplied with the three associated valves installed and wired up, the valve circuit being the responsibility of the user. This should cause no difficulties, however, since the lay-out of the turret is such that a variety of valves can be used if desired. For example, one recommended arrangement is to use three high-gain pentodes, one as R.F. amplifier, another as mixer, with suppressor-grid injection, and the third, triode-connected, as oscillator. Alternatively, it is quite practicable to use a normal oscillator-mixer valve, such as an ECH35 or 6K8, if desired, or any arrangement of single-ended valves such as the miniatures, or the new Rimlocks.

The use of the turret is not restricted to communications receivers, as it would also make an excellent converter, the I.F. output on 1600 kc/sec. being fed to a broadcast receiver. A further alternative is to build a straightforward superhet. circuit with an I.F. of 1600 kc/sec. Whether this, or a converter, or a double conversion receiver, with a low second I.F., is decided upon, the performance of the turret is not affected in any way, and it is therefore adaptable to a large number of requirements with equal likelihood of success for any of them.

We can thoroughly recommend this unit as the answer to the receiver problems of a large number of potential users.

FIVE-INCH OSCILLOSCOPE

(Continued from page 8)

up to, say, the second, or third, or fourth, then only the sums which apply to these harmonics need to be worked out. Before going on to describe the calculations, a few words are needed on other matters.

(To be concluded.)

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of New Zealand.

No. 16: A HIGH-STABILITY V.F.O. (PART 1)

At the present time no one will question the desirability in the amateur transmiting shack of a really stable variable frequency oscillator. That is not to say that crystal control is out of date, or no longer desirable, or anything like that. Far from it, for in operating a "ham" station there is little doubt that the advantages of having either type of frequency control are complementary. In the regulations, as they stand at present in this country, there is a somewhat anomalous situation with regard to the V.F.O. in that, officially, it does not exist. That is to say, in any regulation which has as one of its objects the precise control of the equipment referred to, the standard laid down is the crystal-controlled oscillator. That a good V.F.O. can and often does have far better performance in respect to stability than many crystal oscillators is as yet quite unrecognized by the powers-that-be, but we believe that the situation is at present under review.

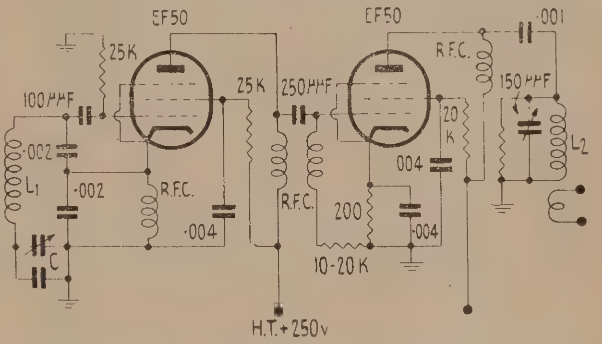
However that is, the fact remains that any amateur who is really keen either has, or wishes he has, a reliable V.F.O. in addition to, or in place of, a selection of crystals. The trouble for most is that they seem to doubt their own ability to build anything that will give them the assurance (sometimes sadly misplaced, be it said) which is conferred by a crystal, especially when multiplying to the higher-frequency bands.

This is unfortunate, for there is no good reason why anyone who has a reasonable appreciation of the factors involved cannot make an oscillator that is at least as stable as his non-temperature-compensated crystal, but in many cases, considerably more so. It is just to illustrate this fact, and to illustrate, too, one of the possible types of construction that can be used, that this article has been prepared.

The Circuit

In the amateur transmitting literature there has recently been quite a stir created by what is known as the Clapp oscillator circuit. This name is derived from one, J. K. Clapp, who described the circuit in the March, 1948, issue of the *Proceedings of the American I.R.E.* We have no confirmation of the following, but we have heard that the circuit is not original with Mr. Clapp, but has been previously described in a British patent, the property of the B.B.C.. If this is so, we have another British development which has been hiding its light under a bushel until its independent discovery elsewhere. At any rate, the name is short, and seems likely to stick, so that, as far as this article is concerned, the Clapp circuit it shall remain.

This circuit, other things being equal, is capable of what is probably the highest stability yet attained in an L-C oscillator. At the same time, it possesses no inherent snags, and is easy to construct. It therefore forms an admirable basis for the V.F.O., the complete circuit of which is given on this page. The valve we have used is an EF50, pentode connected. This is contrary to most of the circuits which have so far appeared, which use a triode, or a triode-connected pentode, but tests have shown that the frequency stability is not impaired at all by the use of the pentode connection. This makes no difference at all to the basic circuit, which in any case uses the triode in such a way that the plate is at ground potential for radio frequencies. Here, the screen of the pentode takes the place of the triode plate, as it is firmly earthed by its bypass condenser and decoupled from the H.T. supply by the screen dropping resistor. The all-important part of the circuit is the way in which the tuned circuit is coupled to the grid-cathode circuit of the valve. The frequency is determined almost entirely by L_1 and C, because the two condensers which complete the tuned circuit are so large. C has been shown as a fixed and a variable condenser in parallel, only to show how the required band is spread over the dial



which drives the variable one. Now, the grid-cathode circuit of the oscillator valve is connected across a 0.002 μfd. condenser, which is so large in comparison with the normal tuning condenser C that the R.F. voltage appearing across it is only a very small portion of the total R.F. voltage developed across the coil. In normal oscillator circuits, the valve is connected across the whole of the tuned circuit, so that the input capacity of the valve finds itself in parallel with the tuning condenser. With this arrangement, reasonable stability can be obtained only by using a tuned circuit with a very low L/C ratio. This makes the condenser as large as possible, so that the valve input capacity and the stray wiring capacities make up as small a proportion of the total circuit capacity as possible, thereby minimizing frequency drift due to long-term changes in the valve's input capacity, through ageing and short-term changes due to heating up after switching on.

In the Clapp circuit, however, we have an arrangement whereby these variable capacities are connected across a condenser which is much larger than any that is likely to be used in an ordinary low L/C ratio oscillator. Better than this, this condenser has the effect of "tapping down" the connection of the valve to the circuit, much as if the coil were tapped only a very small way up from the earthy end, and the grid-cathode circuit were connected across this portion of the coil. Thus, we have two very potent means of minimizing the effect of valve variations on the frequency-determining circuit, both of which act simultaneously. The feedback which causes the circuit to oscillate is obtained by connecting an R.F. choke in the cathode circuit, to act as the D.C. return, and taking the cathode to the junction of the two 0.002 μfd. condensers.

Since the valve is so effectively "tapped down" the tuned circuit, there is another beneficial effect on the frequency stability. It is that the input resistance of the oscillator grid circuit is also rendered almost completely ineffective in so far as lowering the Q of the tuned circuit is concerned. Naturally, the higher the effective Q of the circuit, the more stable any oscillator is, and in this circuit the Q of the circuit with the oscillator functioning is only very slightly less than the unloaded Q, which is the Q measured without anything at all connected across it. Because of this, we have the seemingly anomalous situation that, within limits, the stability is better the higher the L/C ratio of the circuit. At this stage, it can be pointed out that some people have made "lash-up" versions of the Clapp oscillator, only to find that they could not get it to oscillate at all. When this happens, it is simply an indication that the Q of the coil used is not high enough. In fact, for the circuit to oscillate at all, a very good coil is essential.

When we come to describe the actual construction of this V.F.O., it will be seen that, in order to attain the maximum degree of stability, we use a 3 in. diameter coil, space-wound, and with only the bare minimum of insulating material used in its construction. A simple bakelized paper coil former could have been used with quite good results, and was, in fact, used in our own preliminary experimental work, but the "air-wound" type of construction was decided upon for the finished article, because of its superior temperature stability.

The oscillator operates between 1.75 and 2 mc/sec., and the second EF50 is used as a buffer and frequency multiplier, its plate circuit being tuned to the 80m. band. There is ample output from the oscillator to excite the buffer without tuning the oscillator plate circuit, so that a tuned circuit is saved by this means. The output of the multiplier is in the region of 2 watts with 250v. H.T. on both oscillator and multiplier, and this is ample for driving any existing crystal oscillator stage from which the crystal has been removed, or for exciting the next low-powered multiplier stage of the transmitter.

Keying

In the circuit, no provision has been shown for keying, and those who prefer to key the final stage will not be interested in keying the V.F.O. Should oscillator keying be desired, however, the circuit is quite suitable as it stands. All that is necessary is to insert the key jack between the chassis and the earthy end of the oscillator cathode choke and to add a bypass condenser from chassis to the same end of the choke. This can have a value of 0.004 μfd., and in common with the other bypass condensers in the circuit, should be a good-quality mica condenser. The 200-ohm cathode resistor of the doubler is sufficient to hold the plate and screen currents to safe values with no excitation applied.

Voltage and Current Readings

With the values shown in the circuit, and the coils wound as specified, the following current readings were obtained. Throughout, the H.T.voltage was kept at 250.

Oscillator Grid Current ...... 160 to 300 μa.

Note.—This variation occurs as the tuning is varied over a range well in excess of the required 1.75 to 2.0 mc/sec. and throughout, no perceptible change in power output occurs.

Oscillator Plate Current	6 to 6.4 ma.
Oscillator Screen Current	2 ma.
Doubler Plate Current	8.0 ma. (unloaded)
Doubler Screen Current	5.2 ma. (unloaded)
Doubler Grid Current	250 μa.
Doubler Screen Voltage	125v. (unloaded)

Stability

Although no measurements of long-term stability have been made on the circuit, the short-term stability has been found excellent. The oscillator was received on a heterodyne wavemeter which has a setting accuracy of better than 0.01 per cent., and a short-term drift that is quite negligible, its circuits being temperature-compensated. It was found possible to zero-beat the V.F.O. against the wavemeter, within five minutes of turning the former on, and to find that the drift after half an hour was no more than 15 cycles a second. Also, it was possible to turn the V.F.O. off, and after the valves had cooled off, to switch it on again, and as soon as the oscillator started, the beat-note descended from a maximum of approximately 50 c/sec. to zero in a small fraction of a second. The effect was unlike anything the writer has yet heard, the whole process of regaining the zero-beat condition occupying at most half a second, and all that could be heard was a sort of grunt, so fast did the circuit settle down.

The H.T. voltage could be varied from the normal 250 up to 350 volts without the beat rising higher than 50 c/sec. This indicates that, unless extremely rigid conditions are imposed, it is quite unnecessary to use a regulated power supply, and for amateur work our own opinion is that such is not needed.

In the next "Experimenter" we will give detailed constructional data and photographs of the V.F.O. Also included will be working drawings for the chassis as used in the original model.

OUR GOSSIP COLUMN

MR. LESLIE McMICHAEL, OF LONDON

A recent and most distinguished visitor to New Zealand was Mr. Leslie McMichael, of London, who journeyed to Australia to meet his daughter. The latter accompanied him to New Zealand and then back to England.

Foremost amongst his reasons for crossing the Tasman was Mr. McMichael's desire to visit his oldest friend, Mr. Will Cooke, of Messrs. Cory Wright and Salmon, Wellington.

We had the honour of meeting Mr. McMichael, who expressed great regret at his being unable to make the acquaintance of members of the New Zealand radio industry, on account of ill-health. In a recent letter, however, he intimated that he hoped to return to New Zealand to meet those whose acquaintance circumstances prevented him making on his first visit.

Born in Birkenhead in 1884, Mr. McMichael was first educated privately and subsequently at the Birmingham Technical School. Whilst serving his apprenticeship in electrical engineering, Mr. McMichael made his first experiments in wireless in 1903. By 1911 he possessed one of the principal amateur wireless stations in Great Britain, call sign MXA, with a range of 200 miles, making use of spark coil and rotary gap.

In 1913 he founded the Wireless Society of London (now the Radio Society of Great Britain), with René H. Klein, who has been his associate in experimental work and the radio business from that date to the present day.

With Mr. R. H. Klein, he was responsible for the manufacture of a synthetic galena crystal commercially known as "Radiocite," which was particularly sensitive, and was much used in the years prior to World War I. He became the first vice-chairman of the Wireless Society of London, and, after World War I, honorary secretary of the Radio Society of Great Britain. During the course of the years he has watched the membership of this society grow from the first half-dozen to more than 10,000 as it is to-day, being made a vice-president and in 1945 one of the five honorary members.

McMichael Radio, Ltd., which is considered one of the oldest radio-manufacturing firms in Great Britain, was commenced in 1920, since which date Mr. McMichael has been chairman and managing director of that firm. During its peak periods, up to 1,200 employees have been engaged by this firm at its works at Slough, Buckinghamshire. The London offices are at 190 Strand.

In addition to his commercial work, Mr. McMichael has been prominent in the work of various technical institutions, being the president of the British Institute of Radio Engineers in 1944 and 1945, in which office he was succeeded by Admiral Lord Louis Mountbatten. His considerable interest in the technical institutions in Great Britain and abroad will be noted from the following:

(Continued in next column.)

NEW PRODUCTS

A Philco Personal Portable Radio

The release of Philco Model 89C Personal Portable now gives Philco complete coverage in the portable field.

The Philco Personal Portable is a 4-tube receiver, housed in metal cabinet with rounded ends and is carried by means of shoulder strap incorporating semi-directional aerial. The special superheterodyne circuit features automatic valve control and permeability tuned High "Q" Intermediate Frequency Transformers.

The set is definitely of interest to all who are following the latest developments in portable receivers.

100 kc/sec. I.F. Transformers by Inductance Specialists

Messrs. Inductance Specialists, 202 Thorndon Quay, Wellington, announce that they will very shortly be in production with 100 kc/sec. I.F. transformers, suitable for use in circuits which have appeared recently in this journal, and others from overseas, and which call for I.F. transformers for this frequency. Those who will require these transformers are requested to contact any of the main stockists of "Q" parts, or to write direct to Inductance Specialists.

M.I.E.E. (England), F.Inst.R.E. (U.S.A.), past president Brit. I.R.E., F.R.S.A. (England), past president, founder, and honorary member R.S.G.B. (England), Fellow Television Society (England), F.I.R.E. (Aust.) (granted on his recent visit).

QUESTIONS AND ANSWERS

(Continued from page 18.)

to be under a misapprehension in thinking that the astigmatism controls necessarily have anything at all to do with the time-base circuit, which they have not. A major difficulty is that the E.H.T. supply would have to be increased by several hundred volts to make astigmatism possible.

PANORAMIC ADAPTOR

(Continued from page 33.)

before. On the other hand, if the circuits have been staggered too much, the result will be that the dip is too great for the mixer tuned circuit in the receiver to fill up properly. This time it would be a case of re-tuning T_1, but this time with less added capacity.

The adjustment of T_1 may take a long time, and many trials before the desired result is achieved, but there is nothing difficult about it as long as the systematic procedure we have described above is strictly followed. It is worse than useless to use a random method of adjusting the windings of T_1, as it could take days to get the right answer by this method. It is not recommended that the builder tries to get the response flat over a range as wide as 50 kc/sec. on either side of the centre frequency, as this is not only difficult, but is undesirable from other points of view. Our recommended final sweep, at which the adaptor can be set, and left, is plus and minus 30 kc/sec. or so. At this it will not be found hard to get a reasonably flat response over the whole range, and the frequency scale will be pretty accurately linear. Oversweeping the reactance tube simply results in the centre-signal wandering from the position it should occupy on the trace, so that the same point no longer represents the signal that is being listened to on the receiver. Also, the sensitivity of the adaptor becomes less the wider the sweep, because the rate of the sweep becomes such that th swept oscillator does not dwell long enough on the required conversion frequency for any one signal. After a little experimenting, the operator can decide for himself what extent of sweep suits his purpose best, and set R_{22} at this spot. Then, to complete the setting up, the signal generator can be used to calibrate the trace in terms of frequency, as has been described above.

COMMUNICATIONS RECEIVER

(Continued from page 36.)

with the bandspread one. The whole range of the coil has then been covered. The beauty of this scheme is that the switch mechanism, driving the band-setting condenser, causes this to take up perfectly definite positions, with the result that the main dial can be accurately calibrated for any desired position of the band-set condenser. Thus, if one is an amateur transmitter, interested mainly therefore in the Ham bands, these can be calibrated on the main dial, and all that needs to be done to fetch up on any one band is to insert the appropriate coil and set the band-set condenser to position 1, 2, or 3, or whatever is the right one. If one is a shortwave listener, and thus most interested in the shortwave broadcast bands, these have only to be located after the coils have been wound and the set is in commission, and they can be calibrated on the main dial instead.

(To be concluded.)

BEGINNERS' COURSE

(Continued from page 39.)

A.C. source, such as the mains, a diode in series with a resistor having been placed across the terminals. It is at this point that we can fully realise the usefulness of our graphs, for a new one, Fig. 41, enables us to visualize exactly what happens in this circuit. In Fig. 41 the negative half of the current "wave" is shown dotted. Since the diode can conduct only when the plate is positive, the upper half of Fig. 41 shows the way in which current flows through the diode. When the current swings in the negative direction, no current passes through the circuit, so that for half the time current flows and for the other half there is no current. These pulses of current do not look very much like our picture of direct current shown in Fig. 37, but, for all that, the current now flows only in one direction. It is possible by means of a smoothing circuit to eliminate the ripple, as it is called, from the output of the diode, so that we end up with a current which is both undirectional and constant in value, and is as nearly as we please equivalent to the current delivered by a battery. Just how the smoothing circuit works will have to be left for another article, but its construction is very simple.
